POWER

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What War Means

THE PARALYSIS OF INDUSTRY

Combination Electric and Ice Plant, Kentucky Traction and Terminal Co.

By Warren O. Rogers

SYNOPSIS—A combined electric and ice plant. Electric energy is generated by two 2500-kw. turbo-generators supplied with steam from four 1000-hp. water-tube boilers. The ice plant is a 75-ton capacity exhaust-steam system. Steam for the generator is taken from a 160-hp. turbine which drives a centrifugal pump supplying water to the steam condensers. The ammonia condenser, rectifier and weak-liquor cooler are of the atmospheric type and placed on the boiler-room roof.

Four years ago, or in 1910, the Lexington Railway Co., operated an antiquated power house in which were belt-driven railway generators, vertical steam turbines, etc. In connection with this plant was a 50-ton, steam-driven compression ice plant, all of which had been run about a year under the management of F. W. Bacon, vice-president, and A. A. Robertson, superintendent of production; then the firm of Sargent & Lundy was commissioned to build a new $500,000 power plant. The company was reorganized and is now known as the Kentucky Traction & Terminal Co.

The new plant, at Lexington, Ky., is one of the cleanest and most attractive in the South, and although it has a capacity of but 5000 kw., its layout arrests the attention of the visitor as soon as he enters.

Fig. 1 is a view of the plant from the rear. The structure is of concrete and brick, the concrete reaching on the boiler-room side to a level with the car track. The boiler and the turbine rooms are well lighted by the large windows.

Turbine Room

The two 2500-kw. turbo-generators, Fig. 2, are placed crosswise of the turbine room, with ample room for the operator to get about and to make the repairs. The plan and elevation, Fig. 3, show the general arrangement of the apparatus on the turbine-floor level. At the far end of the plan view is No. 1 turbine, with its 9 and 22 by 16-in. air pump. Next, there are three turbine-driven circulating pumps, two of which, placed crosswise of the room, are 16 in. in size and have a capacity of 8000 gal. of water per min. at 1000 r.p.m. Each is driven by a 160-hp., single-stage horizontal turbine. The third pump, placed lengthwise of the room in line with

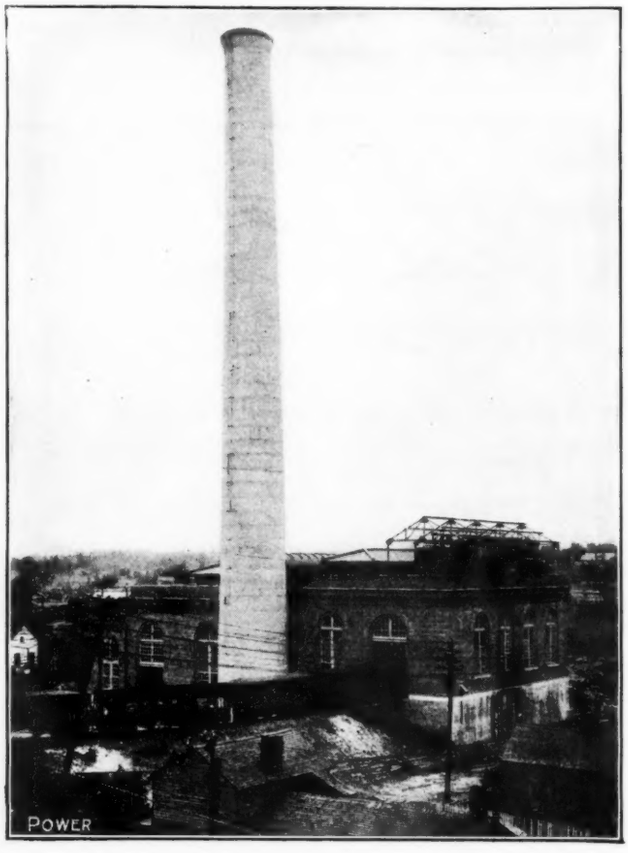


Fig. 1. View of the Power Plant from the Rear

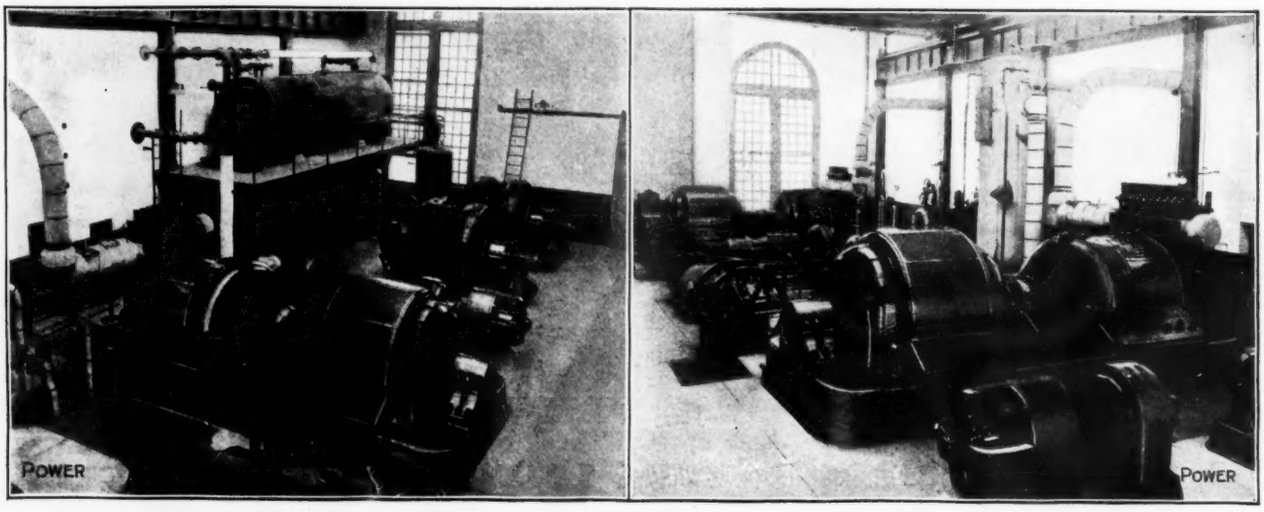


Fig. 2. Two Views of the Turbine Room, Showing the General Layout of the Various Units

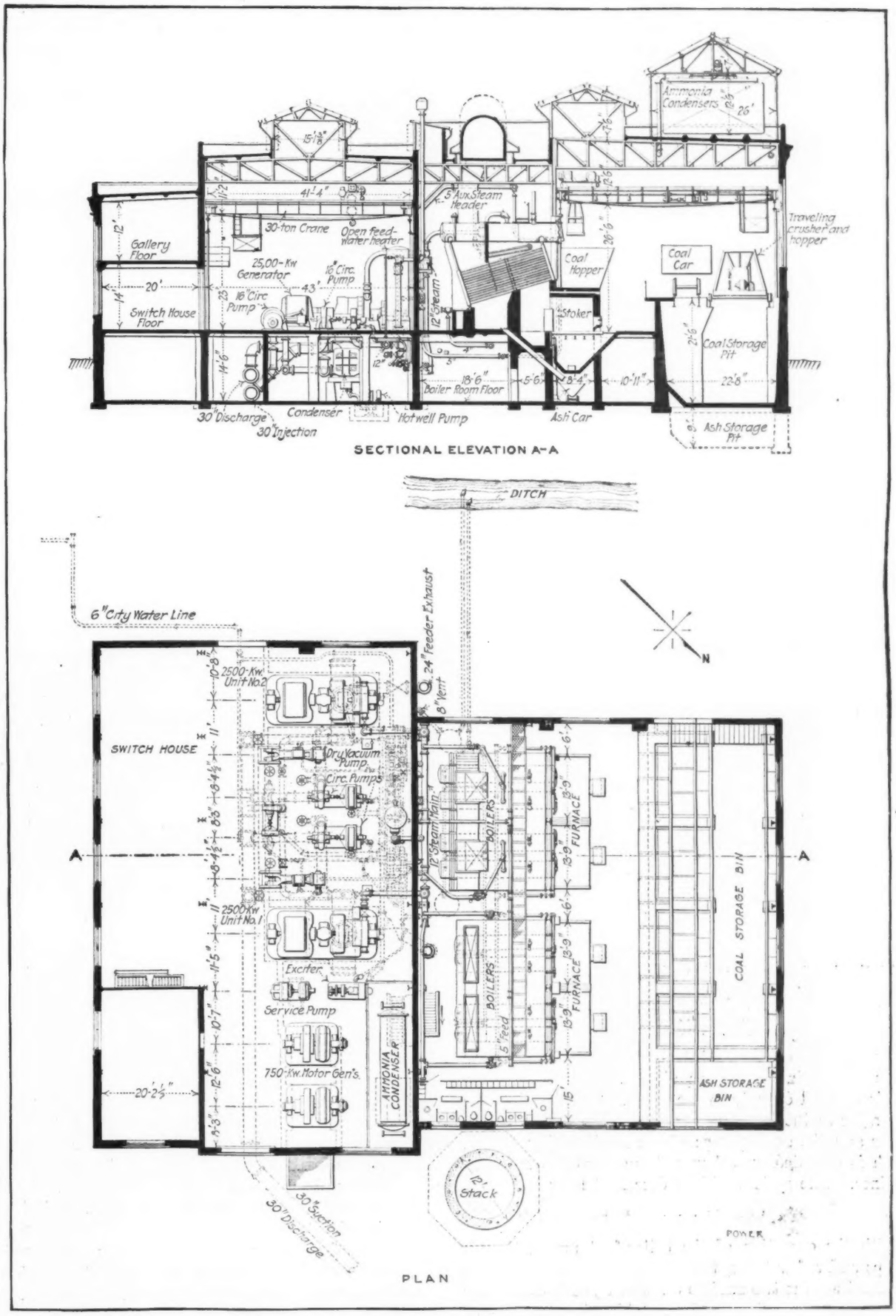


FIG. 3. PLAN AND ELEVATION OF THE LEXINGTON, KY., POWER PLANT

the crank end of the two air pumps, is a 10-in. pump, with a capacity of 3000 gal. per min., and is driven by a 60-hp., single-stage turbine.

The second air pump is of the same size as that used with No. 1 condenser. No. 2 turbine comes next and lines up with No. 1 unit. At the right of No. 2 turbine are two exciter units; one is a turbo-generator set of 75-kw. capacity, 125 volts, at 3300 r.p.m., the other is an induction motor-generator set of 75-kw. capacity, 125 volts at 1165 r.p.m.

Two 1075-hp. synchronous motor sets deliver 600-volt current at 514 r.p.m. for street-car service in the heart of the city, the high voltage of the main generator being transmitted to substations for distant points.

Next to the wall separating the boiler and turbine rooms is a 14 and 8 by 15-in. duplex boiler-feed pump. When the plant was first built, there were two pumps, one on each side of the heater, but one has been and the one in the turbine room will be removed to the basement so that the turbine room may not be disfigured by water leakage around the pumps.

the main turbines. Exhaust steam enters the top of the condensers at the center through a 5-ft. diameter corrugated expansion joint. Condensate from the condenser passes to the hotwell through a 6 in. line and is pumped to the heater through a 3-in. pipe. Each turbine exhaust is connected to a 24-in. atmospheric exhaust extending through the basement to the boiler-room side of the partition wall, where it is run through the roof.

Water from the cooling pond flows by gravity through a 40-in. concrete pipe to a well in the power house from which a 30-in. cast-iron pipe runs to a point below the large circulating pumps and which are connected by 20-in. pipes with the main suction line. The discharge lines from these two pumps are each 20 in. in diameter and the suction line to the small circulating pump is 14 in. in diameter. The 12-in. discharge pipe connects with the discharge pipe of each of the large circulating pumps. Valves with extension stems and floor stands are so arranged that the small pump can be operated with either condenser, or in conjunction with either of the large pumps. The dis-

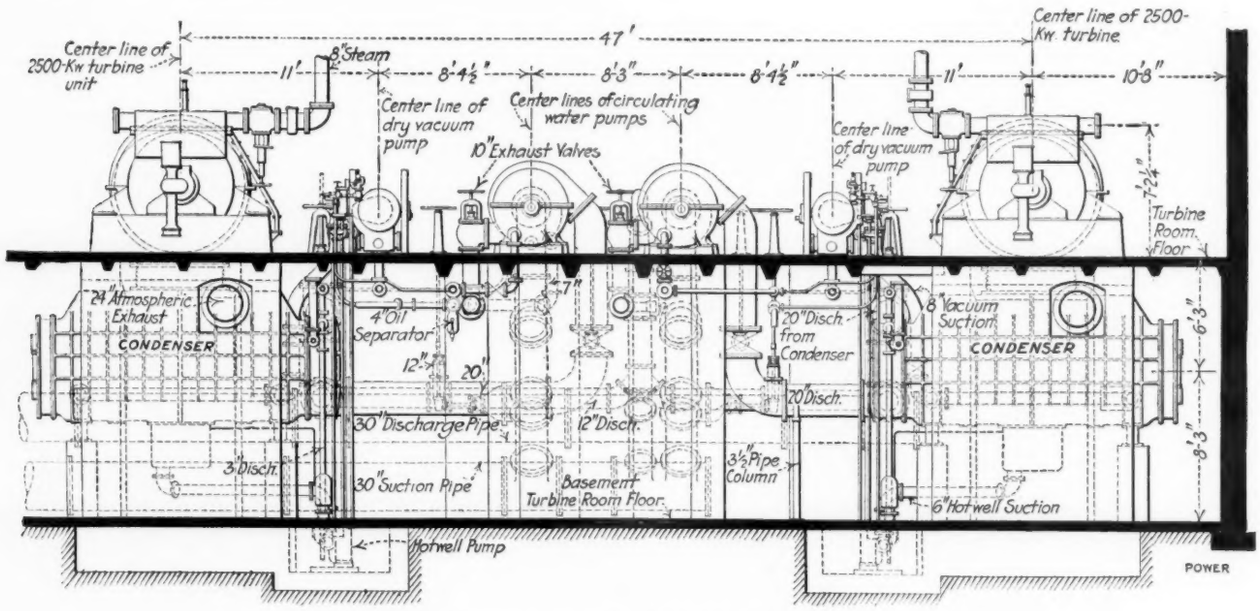


FIG. 4. ELEVATION OF THE TURBINE AND PUMP PIPING

At the head end of each main turbine is a vertical 6 and 10 by 12-in. hotwell pump, which removes the hot water from the condenser hotwell and forces it to the 1000-hp. open heater, next to the boiler-room wall. As only the steam cylinder of the hot-well pump protrudes above the turbine-room floor, all leakage from the pump end is drained directly to the sump. This is all of the apparatus in the turbine room except the ammonia generator and the aqua pumps of the refrigerating system, which is operated on exhaust steam from the auxiliary turbines. The system will be described later on.

PIPING

With the exception of the boiler-feed pump, hotwell pumps and a few traps, the only other apparatus in the basement are the two surface condensers, each containing 7500 sq.ft. of cooling surface. This gives a ratio of turbine capacity to condenser cooling surface of 1 to 3. The condensers in the basement are at right angles to

charge and suction lines of the latter are also fitted with extension valve stems and floor stands.

Steam for the two main turbines is taken from the 12-in. main header in the boiler room, through 8-in. long-radius bend pipes. The auxiliaries take steam from a 5-in. auxiliary header in the basement, piped to the main steam header at each end. The two large and the small circulating pumps receive steam through a 3½- and 2½-in. line, respectively; the exhaust lines are 10- and 7-in., connected with a 12-in. exhaust header, piped to the open heater and to an 8-in. atmospheric exhaust. An elevation of the piping of the turbines and auxiliaries is shown in Fig. 4.

Owing to the scarcity of cooling water, a spray cooling pond has been built 612 ft. from the power plant. This is because the old reciprocating plant, now dismantled, was at the end of the old cooling pond, and as the new plant would require more pond area, an addition was made. The old and new ponds are divided by a dam; the two

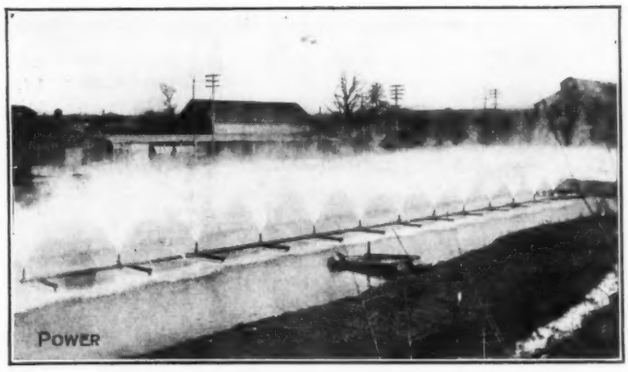


FIG. 5. SPRAY-COOLING POND, OLD PLANT AT THE RIGHT

combined are about 300 ft. long with an average width of 125 ft. and a capacity of 3,000,000 gal. In all there are 109 spray nozzles with a total capacity of 20,000 gal. of water per min., and cooling it 15 to 20 deg. A view of the pond is shown in Fig. 5.

BOILER ROOM

The boiler room contains four 1000-hp. water-tube boilers. Each has 5000 sq.ft. of heating surface and carries 200 lb. of steam superheated 125 deg. Dutch-oven furnaces are employed with automatic stokers 8 ft. 9 in. long and 12 ft. wide, a total of 105 sq.ft., or 1 sq.ft. of grate area to 47.6 sq.ft. of boiler-heating surface.

Above the stokers is a coal hopper, which is kept supplied by means of a 5-ton traveling crane and grab bucket. Run-of-mine coal is delivered to the boiler room in railroad cars, Fig. 1, and is unloaded into a 1000-ton coal-storage pit. Adjoining this pit is a second of the same capacity, over which a traveling crusher and hopper runs on a wide-gage track. It is driven by a 40-hp. mill-type motor. The crane is equipped with a 30-hp. closing motor, a 10-hp. running service motor, a 20-hp. bridge motor and a 40-hp. motor for hoisting.

The second bridge-wall of the boiler furnaces is centered under the first baffle-wall, and extends to the bottom of the furnace. Back of this bridge-wall is an outlet for discharging soot from the rear end of the boiler setting into an ash car on a narrow-gage track, built under the ash-pit hoppers, and running lengthwise of the boiler-room basement. The ash car is thus made to serve the double purpose of handling ashes and soot from the same track. Ashes are discharged into a concrete 75-sq.yd. storage pit at one end of the coal-storage pits, Fig. 3, and the accumulation is hoisted by the crane bucket and loaded into cars for final removal.

Each boiler is piped to the main 12-in. header by a 6-in. lead, which connects at the boiler end with the outlet from the superheaters. Feed water is supplied by two independent 5-in. feed lines, dropping to the basement from the main feed header back of the boilers and connecting with a second header in the basement, from which separate feed lines run to each boiler. The auxiliary feed lines run up and are brought over the top of the boilers to a header from which separate feed lines are piped to the boilers. This arrangement provides reasonably reliable service against feed-water failure and at the same time removes a mass of feed piping from the boiler fronts where it would interfere with repair work, etc.

Gases in reaching the smoke uptake from the furnace flow through three passes in the boiler and discharge at the top at the rear end into a 4x11-ft. lined steel uptake, having an area of 44 sq.ft. The main smoke flue, Fig. 6, on the roof, is made of sheet steel, lined with firebrick and is rounded on top. The flue is 8 ft. 6 in. wide and is 8 ft. 6 in. and 12 ft. 9 in. high at the small and large sections, respectively. This smoke flue extends the length of the boiler house and enters a concrete chimney 215 ft. high with a 12-ft. diameter at the top. This gives a stack area of 113 sq.ft., or a ratio of grate and stack area of 1 to 1.076.

The boiler tubes are kept clean by a system of tube blowers.

ELECTRICAL APPARATUS

On the turbine side of the building are the switchboard bay and gallery, which, with the basement level, gives three floors for the electrical control apparatus. The main switchboard, Fig. 7, is in a bay, upon which are mounted the necessary recording and indicating instruments, switches, etc. All high-voltage switches are operated by remote control. The circuit-breakers, oil switches and busbars are housed in brick compartments in the basement, Figs. 8 and 9.

REFRIGERATING APPARATUS

In conjunction with the electrical generation of power, byproduct ice is made. This is sold at retail by the company in Lexington and to ice plants in the neighborhood. During the winter months, when the local demand for ice is small, the company furnishes ice to its competitors in Lexington and to ice companies in the general territory.

The economical production of ice by the combined electric ice plant is due to the absorption ice system, which uses exhaust steam in the generator that has already performed work in the electric plant. The ice is shipped in the company's ice cars, which are run over the interurban lines leading to the surrounding country. Due to the constant demand for ice, the plant is operated at nearly full-rated capacity throughout the year. The operating cost per ton of ice is low.

The new power plant is about 600 ft. from the tank room and storage house. The new ice-storage house has

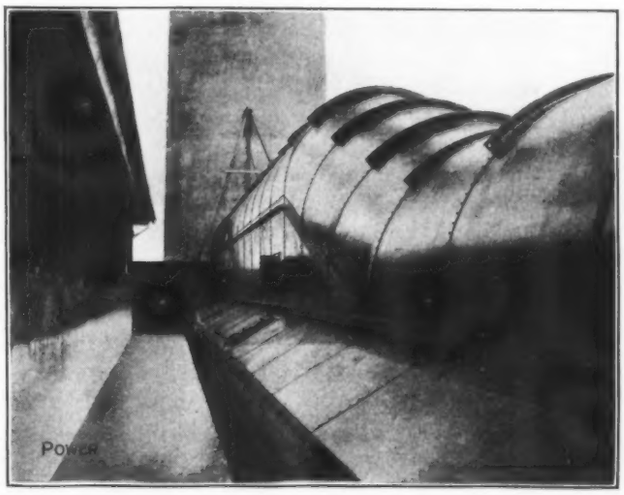


FIG. 6. SMOKE FLUE ON THE ROOF OF THE BOILER HOUSE

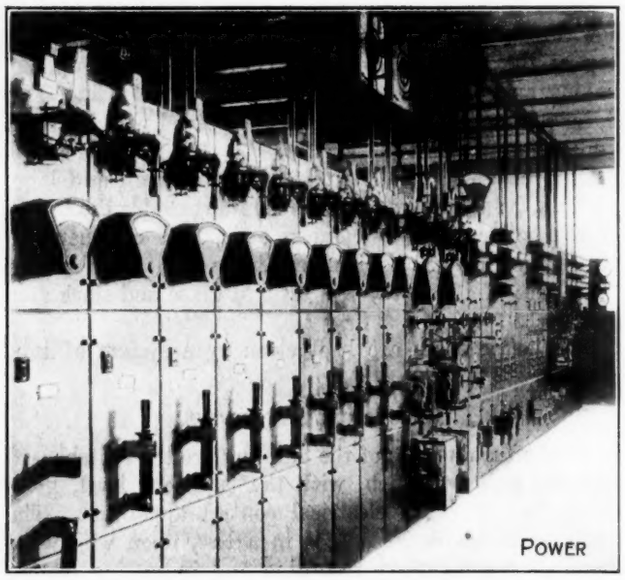


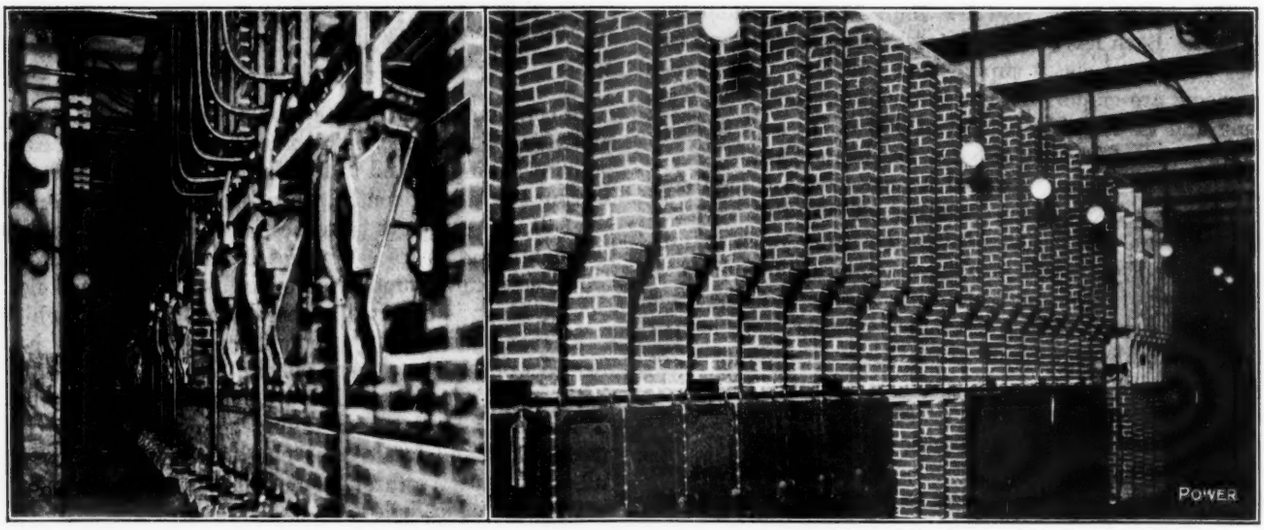
FIG. 7. MAIN OPERATING SWITCHBOARD

each 10 pipes high; below are 28 stands of absorber coils, each 12 pipes high. Fig. 10 shows the coils as arranged on the boiler-house roof. Exhaust steam for the generator is obtained from one of the 160-hp. turbines driving the rotary pumps supplying water to the steam condenser.

The system is guaranteed to operate with the condensing water at 95 deg. F.; this has been exceeded. The temperature of the water averages 60 deg. in winter and goes as high as 103 in summer when the system operates at full capacity. The average summer temperature is 98 deg.

The exhaust steam from the 160-hp. turbine used in the generator of course creates a back pressure on the turbine, but this does not cause the steam consumption of the turbine to exceed 20 lb. per hr. per ton of ice during the summer months. During the winter, the increase is about 3 lb. per hr. per ton of ice, as the back pressure is decreased.

As the atmospheric condensers, absorbers, rectifiers, exchanger and weak-liquor cooler are on the roof and the generator at one end of the turbine room and elevated above a stairway, it was not necessary to make the build-



FIGS. 8 AND 9. SWITCHES AND BUSBAR ARRANGEMENT IN THE BASEMENT OF THE POWER HOUSE

a capacity of 5000 tons; it is constructed of two layers of 8-in. hollow tile, insulated with sheet cork. The building is 51 by 61 ft. and 68 ft. high.

The distance between the old and the new plants brought up an interesting and perplexing problem as to the type of machinery to put in. After due consideration, a 75-ton exhaust-steam, ice-making machine, capable of making 72 tons of ice on the two old tanks, each of 412 cans, was decided upon.

The generator of the ice plant is shown at the rear of the left view of Fig. 2, mounted on a platform. Ammonia gas is driven off from aqua ammonia and sufficient pressure is produced so that the gas, after being dried in the rectifiers, is condensed, making liquid anhydrous ammonia, which passes through a 1½-in. line to the old power house, where it is expanded through coils in the ice tanks. The expanded gas from these coils, after passing through the coils in the distilled-water-storage tanks, returns to the absorber on the roof through a 6-in. line. The atmospheric condenser consists of 28 stands of coils,

FIG. 10. CONDENSER, RECTIFIER AND EXCHANGER ON ROOF OF BOILER ROOM

PRINCIPAL EQUIPMENT OF THE COMBINATION ELECTRIC AND ICE PLANT OF THE KENTUCKY TRACTION AND TERMINAL CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbo-generators	Horizontal	2500 kw	Main units	1800 r.p.m., 200 lb. steam, 3 phase, 60 cycle, 4000, 2300 volts	General Electric Co.
1	Motor-generator	Induction, d. c.	75 kw	Exciter for main turbines	1165 r.p.m., 3 phase, 60 cycle, 125 volts	General Electric Co.
1	Turbo-generator	Curtis, d. c.	75 kw	Exciter for main turbines	3300 r.p.m., 200 lb. steam, 125 volts, 600 amp.	General Electric Co.
2	Pumps	Dry air	9x22x16-in.	On condensers	Non-condensing, rotating	Wheeler Condenser & Eng. Co.
2	Condensers	Surface	7500 sq.ft. cooling surface	With main turbines	28-29-in. vacuum	Wheeler Condenser & Eng. Co.
2	Pumps	Centrifugal	16-in., 8,000 gal. per min.	Circulating water for condensers	1000 r.p.m. turbine driven	Wheeler Condenser & Eng. Co.
1	Pump	Centrifugal	10-in., 3000 gal.	Circulating water for condensers	1300 r.p.m. turbine driven	Wheeler Condenser & Eng. Co.
2	Turbines	Kerr	160 hp.	Driving circulating pumps	1000 r.p.m., 200 lb. steam	Kerr Turbine Co.
1	Turbine	Kerr	60 hp.	Driving circulating pump	1300 r.p.m., 200 lb. steam	Kerr Turbine Co.
2	Motor-generators	Synchronous, d. c. g.	1075 hp., 750 kw.	Railway circuit	514 r.p.m., 514 volts, 3 phase, 60 cycle, d. c. gen., 600 volts	General Electric Co.
2	Pumps	Vertical	6x10x12-in.	Pumping hot-well water	200 lb. steam	Warren Steam Pump Co.
1	Heater	Open	4000 hp.	Heating feed water	Heating feed water to 200 deg.	Pheonix Iron Co.
2	Boilers	B. & W.	1000 hp.	Steam generators	200 lb. steam, 125 deg. superheat	Babcock & Wilcox Co.
2	Boilers	Edge Moor	1000 hp.	Steam generators	200 lb. steam, 125 deg. superheat	Edge Moor Iron Works.
4	Stokers	Murphy				Murphy Iron Works.
4	Superheaters	Foster		Superheating steam	125 deg.	Power Specialty Co.
1	Crane	Traveling	5 ton	Handling coal	Motor operated, intermittent	Toledo Bridge & Crane Co.
1	Chimney	Concrete	215 ft. high, 12 ft. inside dia.	Furnace gases	Natural draft	M. W. Kellogg Co.
4	Blowers	Vulcan		Boiler tubes	Steam at boiler pressure	Vulcan Soot Cleaner Co.
1	Ref. System	Absorption	75 ton	Ice making	Exhaust steam	The Carbondale Machine Co.
2	Pumps	Simplex	16x8x16	Aqua from receiver to generator	One held as reserve	The Carbondale Machine Co.
1	Ejector	Duplex		Sump water	Intermittent	Yeomans Bros.
1	Crane	Toledo	30 ton	Turbine room	Electrically	Toledo Bridge and Crane Co.

ing any larger than required for the electrical apparatus. The 16 and 8 by 16-in. aqua pumps are in duplicate and are under the platform supporting the generator.

Drainage from all the departments goes to a sump from which the water is handled by an electric sewage ejector. All high-pressure drips are piped to a receiver and the condensate is returned to the boilers. A 30-ton crane spans the turbine room and is electrically equipped.

Will Quizz, Jr.

SYNOPSIS—The injector fails to work with the water-supply valve wide open. Will throttles the supply and gets it going, but does not know why it was necessary. He, as usual, asks Chief Teller.

"I put the injector on while I did some work on the feed pump last night, chief. I thought I was wise to all of its moods, but it did not act as it used to. The extra pressure on the water main seems to have something to do with it, because I had to close the water-supply valve part way before it would take hold. We used to run with it wide open. What is the reason?"

"The increased pressure, Will, gives the injector more work or water than it can handle. For example, a steam jet or nozzle of the same size acting on the rotor of a turbine, used to pump water into a boiler, will handle a certain amount of water and no more. The same is true of the jet in the injector. If you flood it with more water than can be given the necessary velocity, it will kick, of course. If the turbine drove a generator and you tried to draw amperes beyond its power, the voltage would drop as the speed reduced, but with the injector the speed, the velocity of the water, must be kept up to that necessary to equal or exceed the counter pressure and pipe friction.

"Suppose you had an ejector using steam at 10-lb. pressure at the jet with a length of pipe screwed into the discharge end, and a funnel in the side opening. If you introduced sand through the funnel in front of the jet it would partake of some of the velocity of the steam and be discharged from the pipe end. If, however, you increased the quantity of the sand and elevated the pipe end, you would soon reach the limit of the capacity of the jet and no sand would be discharged.

"Now, just what happened? In the first place, the sand, which had no motion, received or absorbed enough of the velocity of the steam to reach the end of the pipe against whatever resistance there was. Then as the amount of sand was increased and the elevation added, the velocity of the discharge diminished until the kinetic energy of the jet was all absorbed before the end of the pipe was reached.

"The whole operation would stop just as the injector stopped. If you could have reduced the resistance to the discharge from the injector, it would work with the inlet valve wide open, but since that could not be done and still feed the boiler from which the steam came, then, of course, the thing to do was to reduce the amount of supply. If it cannot handle the full amount, give it less weight of water. Why not? This also holds good when the steam pressure is down.

"Think of the water in the pipe as a long arrow, driven forward by the jet, which must have sufficient velocity to 'penetrate' into the boiler against the pressure and friction resistance. The pressure represents the feet elevation, and the weight of water handled the pounds, so that it becomes foot-pounds of work.

"By the way, the injector is one of the most efficient pieces of steam apparatus known. When considered as a boiler feeder and heater combined it is 100 per cent. efficient less the small loss by radiation, which goes to show that the whole case is not stated when it is said that it is not an economical boiler feeder. Of course, if there is exhaust going to waste, then using live steam to heat the water as well as to put it into the boiler by means of an injector is not the proper thing, but in many cases an exhaust-steam injector might be used. Look up the subject of exhaust injectors, which seems to be a paradox."

1200-Ton Chimney on Structural-Steel Support

By J. C. Lathrop

SYNOPSIS—A radial brick chimney, 250 ft. high, 25 ft. in diameter and weighing about 1200 tons, is erected and supported above the boilers on structural steelwork. The preliminary work was begun Apr. 23 and completed on June 12. The cost for all labor was $2117.25. Twenty carloads of chimney brick and three of firebrick were used.

The construction of a radial brick chimney on structural-steel supports at the Westport power station of the Consolidated Gas, Electric Light & Power Co., of Baltimore, has created considerable interest. This chimney will serve 12 water-tube boilers, each having a nominal rating of 1000 hp. and will probably be forced to 300 per cent. of rating at times. Six of these boilers are now on one side of the stack and the other six will be placed in an addition to the building which will be built adjacent to the side shown in Figs. 2 and 3.

A chimney with an internal diameter of about 20 ft., rising 250 ft. above the grates, was required, the stack to be supported upon a steel deck at the roof level so that the space in the boiler-room basement and main floor could be used for pumps and other auxiliaries.

Reason for Selection of Brick Chimney

It was at first thought that the most economical de-

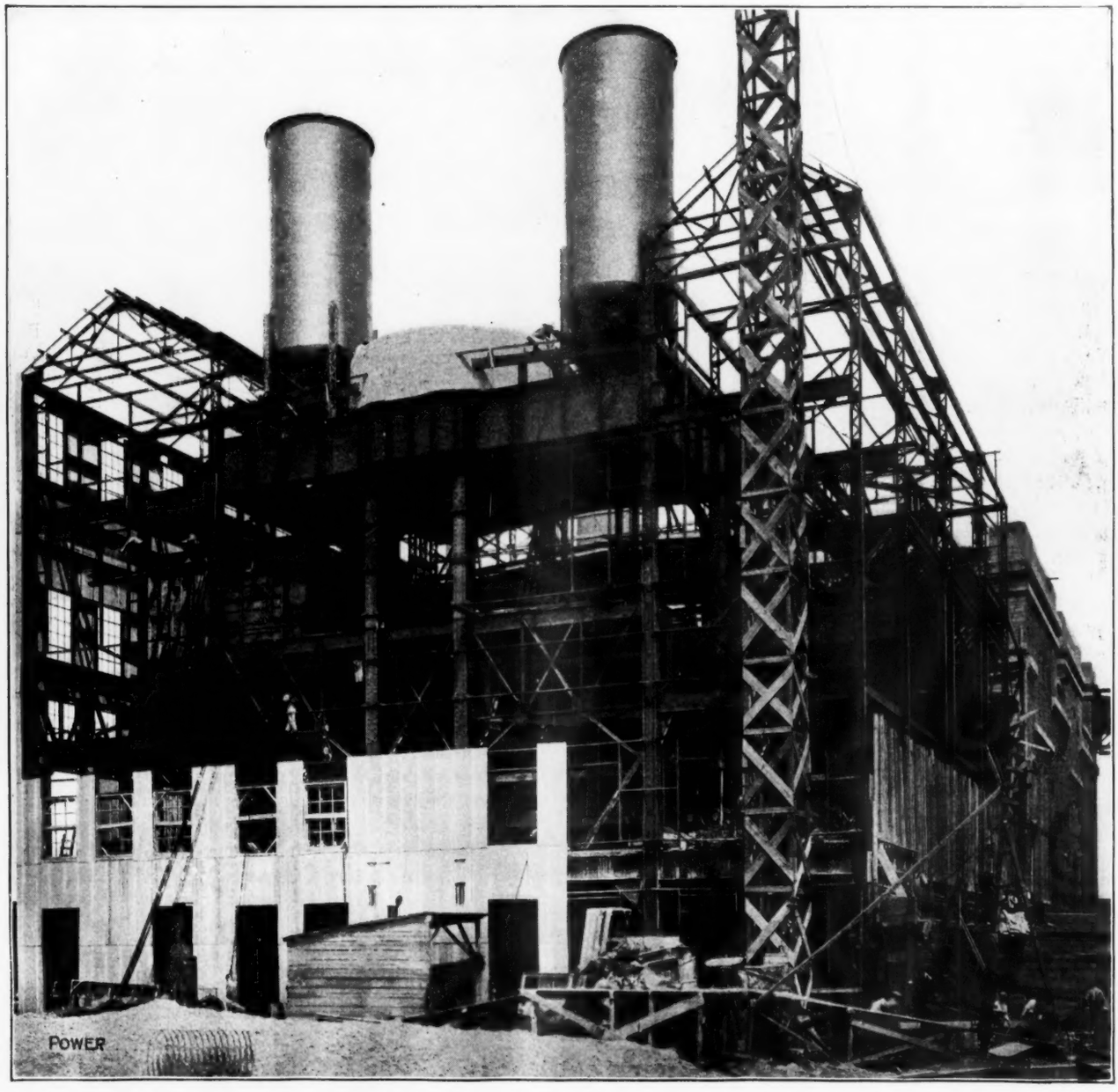


Fig. 1. April 27; about 7 Ft. of Chimney Completed. Note the Steel Supports

sign would be a brick-lined steel stack, carried upon the structural-steel work of the building. Such stacks are quite common in New York and other large cities and have given good service. There was doubt, however, as to the ultimate economy of this construction as compared with a radial brick chimney supported upon similar steel work. Therefore an estimate was prepared for each design based upon a minimum thickness of steel of ¼ in. signed for more than twice the total load in the case of a steel stack. In addition, a brick chimney appears much more pleasing than a steel stack, and there is little doubt that the durability is much greater.

Structural-Steel Support

The base rests directly upon eight steel girders 72 in. deep, six resting upon the four interior columns, the

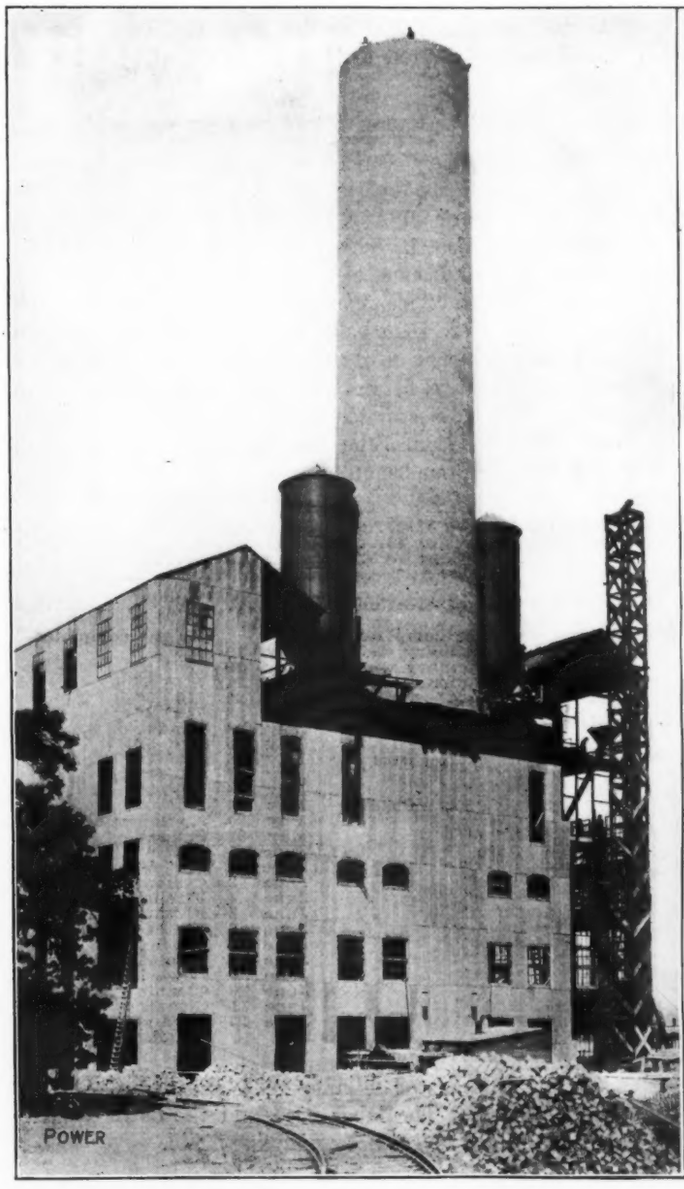


Fig. 2. Chimney about Half Completed

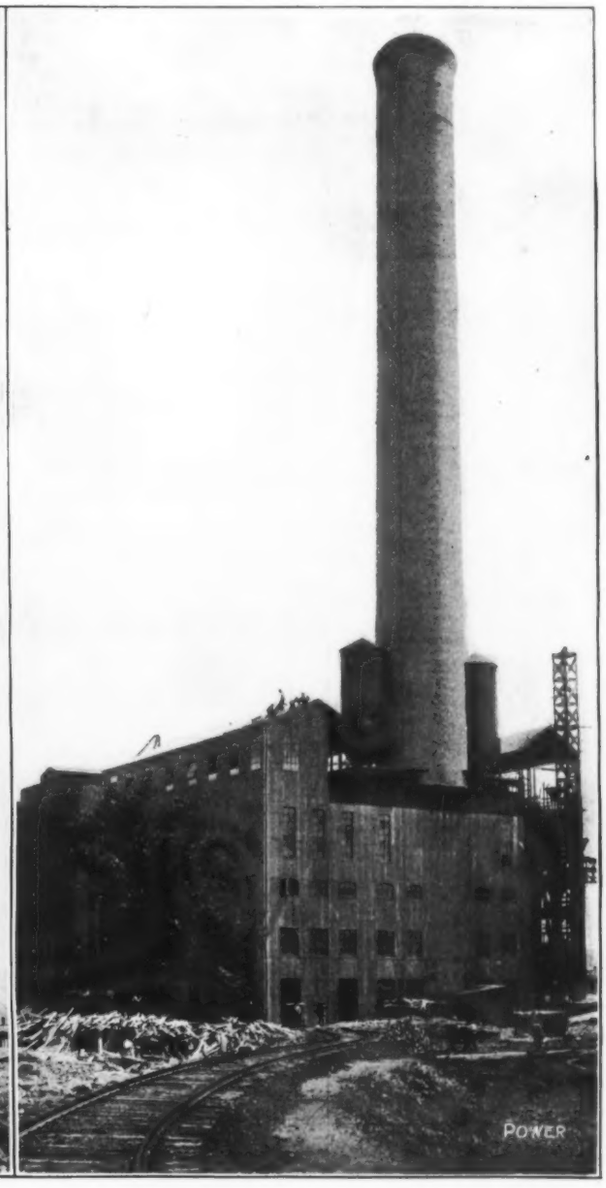


Fig. 3. Completed June 12

Although the comparative estimate was based upon a higher price for a radial brick chimney than was named in the final contract, the cost of the brick chimney, with the additional steel work, together with the foundation, piling, etc., was less than that for the steel stack with brick lining. Furthermore, it would not have been good policy to use metal as thin as ¼ in., even in the upper portion of a chimney of this size. It must also be remembered that the wind strains are about the same in either case, and while, with the brick construction, the foundations were designed for about double the total dead load on that account, they would need to be de-

ether two framing into other girders which transmit a portion of the load to four additional columns. This construction is shown in Fig. 1. Horizontal wind bracing was so provided between these eight columns that the wind strains are carried to the foundation through the columns, although the direct weight of the stack is mainly supported by the four center columns.

The bracing, designed to carry the horizontal strains from the wind on the stack to the ground, also is shown in Fig. 1. The lattice girders also support a floor at the level 24 ft. 9 in. above the main boiler-room floor.

The four center columns are supported upon a single monolithic, reinforced-concrete foundation. The loads are transmitted to this foundation from the columns through a double system of grillage consisting of four 24-in. I-beams 8 ft. long under each column, these resting on a second layer of twenty-six 18-in. I-beams 21 ft. 8 in.

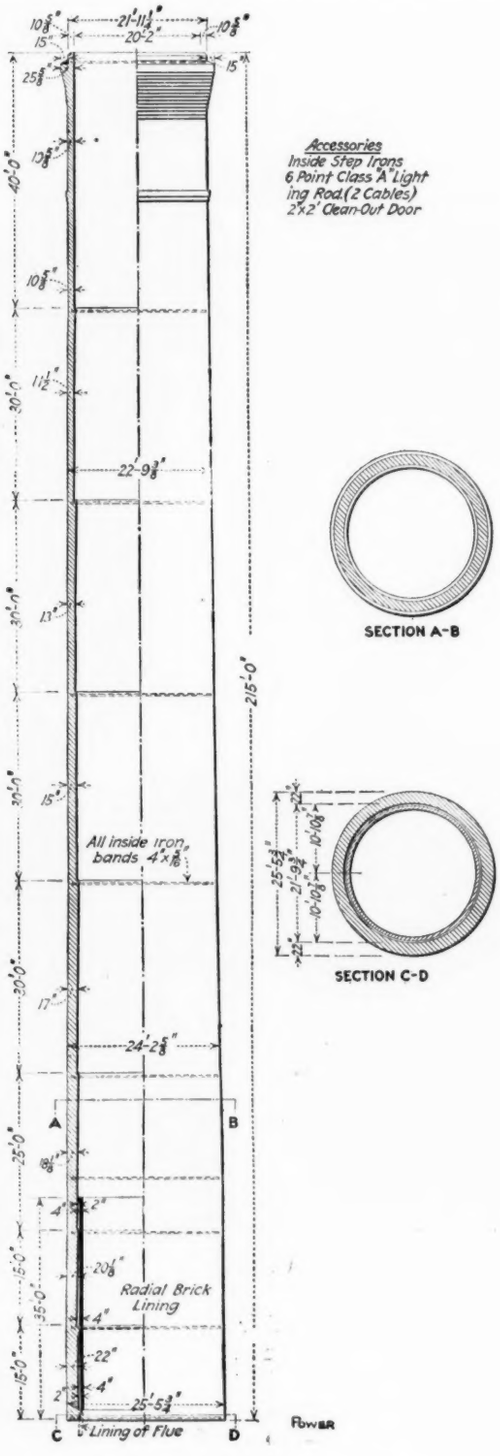


FIG. 4. DIMENSIONS OF STACK

long. The lower section of each column weighs 438.7 lb. per ft. and is composed of one 14-in. Bethelehem H-column, with two 18-in. plates each 2¾ in. thick.

The entire foundation is held by piles from 10 to 50 ft. in length. As these piles evidently rest upon the bank of an old stream filled with silt; it caused some apprehension until the chimney had been entirely completed and no settlement whatever was detected.

The chimney is 20 ft. 2 in. in diameter inside and rises to a height 215 ft. above the steel supporting girders; the outside diameter at the base is 28 ft. 5¾ in.; the complete stack weighs about 1200 tons; see Fig. 3.

The usual method of erection was adopted by the contractor, the Alphons Custodis Chimney Construction Co. A platform was raised as the work proceeded, the material being delivered to it in a tub raised by a hoisting engine.

LABOR AND ERECTION

The preliminary work was begun on Apr. 17 and it was completed about Apr. 23. Fig. 1 shows the condition of the work on Apr. 27, when 6 ft. of the chimney proper was finished. This portion was the most difficult, as several roof beams, etc., had to be put into place in the brick work. The photograph Fig. 2 shows the chimney a little more than half built, while Fig. 3 shows the stack as completed on June 12, 1914. The cement cap was put on June 3, and the final work of placing the firebrick lining, cleaning up and removing the machinery, etc., was done from June 4 to 12, eight weeks from the time this work was begun.

LABOR COST

Foreman, 40 days at $8	$320.00
Engineer, 40 days at $5	200.00
Bricklayers, 1303 hr. at 65c	846.95
Laborers, 3752 hr. at 20c	750.40
Total cost of erection	$2117.35

Date	Height completed
April 23	Preliminary work
April 24	Preliminary work
April 25	Preliminary work
April 26	Sunday
April 27	6′ 0″
April 28	13′ 5″
April 29	17′ 3″
April 30	Unloading cars
May 1	24′ 1″
May 2	28′ 7″
May 3	Sunday; unloading cars
May 4	36′ 0″
May 5	Rain
May 6	42′ 8″
May 7	48′ 7″
May 8	54′ 6″
May 9	58′ 6″
May 10	Sunday
May 11	66′ 6″
May 12	75′ 3″
May 13	83′ 3″
May 14	93′ 3″
May 15	101′ 9″
May 16	106′ 3″
May 17	Sunday
May 18	116′ 3″
May 19	125′ 11″
May 20	135′ 5″
May 21	144′ 5″
May 22	153′ 5″
May 23	159′ 4″
May 24	Sunday
May 25	169′ 6″
May 26	178′ 6″
May 27	190′ 0″
May 28	199′ 0″
May 29	204′ 0″
May 30	No work; high wind
May 31	Sunday
June 1	212′ 0″
June 2	215′ 0″
June 3	Cement cap
June 4	Firebrick lining
June 5	Firebrick lining
June 6	Firebrick lining
June 7	Sunday
June 8	Firebrick lining
June 9	Lowering scaffold
June 10	Cleaning up
June 11	Cleaning up
June 12	Loading engine and tools

Twenty carloads of chimney brick and two of firebrick were necessary. The labor used and the daily progress made are given in the accompanying table.

Ampère and His Work—André Marie Ampère was a distinguished French physicist and mathematician (1775 to 1836). His three most important contributions to knowledge were the following:

1. His clear analysis and mathematical description of the work of Oersted. It was in the fall of 1820 that Oersted discovered the effect of an electric current upon a magnetic needle. In less than a week after learning of this discovery Ampère had reduced the description to a mathematical formula.

2. The discovery that electric currents produced a magnetic effect upon each other; so that when the currents in two wires are flowing in parallel directions, they attract each other; but when flowing in opposite directions, repel each other.

3. The hypothesis that magnetic substances are made up of molecules in which electric currents circulate, but meet no resistance, these currents are therefore permanent. According to this view, a body is magnetized when its molecules are made to face more or less in one direction.

Fedeler Dust Collector

The importance of an efficient dust collector cannot be overestimated, because with the ever-increasing amount of coal burned in boiler furnaces the floating dust not only becomes injurious to health, but its action is destructive. Dust has caused short-circuits between the electrical connections of switch and panel boards and poor oil has been blamed for hot bearings, when, as a matter of fact, sufficient precaution had not been taken to protect the bearings and engine room from dust. Gas engines in power houses are frequently injured by dust which enters with the gas and tends to ruin the valves and cylinders.

Dust is, as a rule, a particle of solid matter floating in moving air; when the air current is arrested the dust settles, and to move this particle a definite amount of energy is required. Therefore, the air always moves a little ahead and faster than the dust, and when the speed of the air is suddenly arrested, the dust keeps on going until the energy with which it was charged is expended.

In the dust collector here illustrated, the separation of dust from the air depends upon giving the air a sudden change of direction or speed. Office fans become dirty at the outer end of the blades, and as they give motion to the air, it would appear that the dust always lags behind the motion of the air.

The Fedeler blower and dust collector, Figs. 1 and 2, is manufactured by John H. Fedeler, 11 West Fortieth St., New York City. It is built with a drum containing a large number of fan blades which revolve in a casing, made with several compartments for collecting the dust. Holes are formed in the drum to allow the dust to be thrown out. As the heavier particles are thrown out first, the drum is divided into sections, so that the different weights of dust particles are drawn off separately.

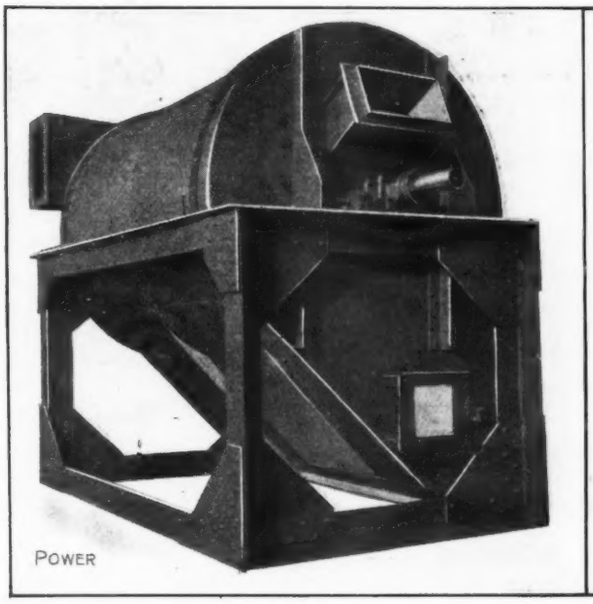


FIG. 1. FRONT AND END VIEW OF THE FEDELER DUST COLLECTOR

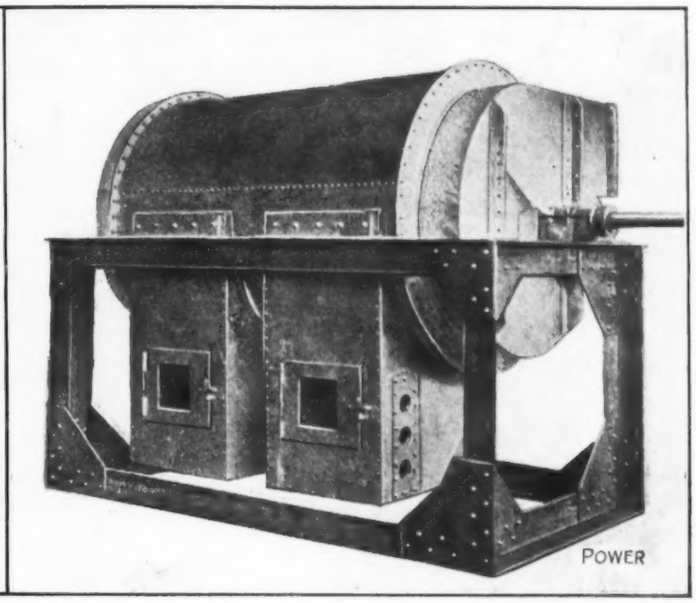


FIG. 2. REAR AND DISCHARGE END OF THE DUST COLLECTOR

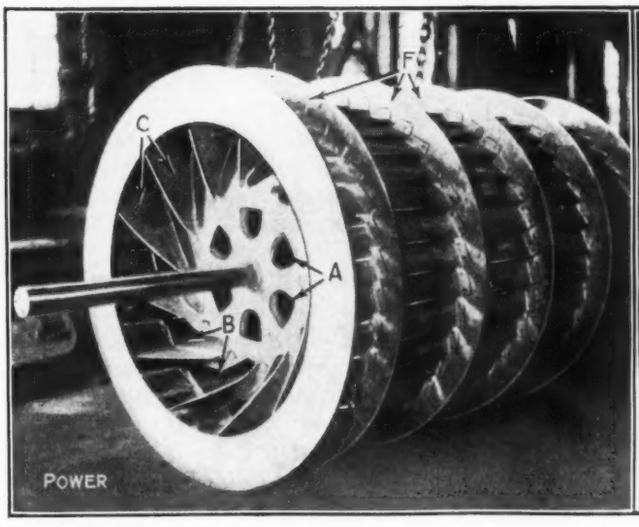


FIG. 3. INTAKE END OF REVOLVING DRUM

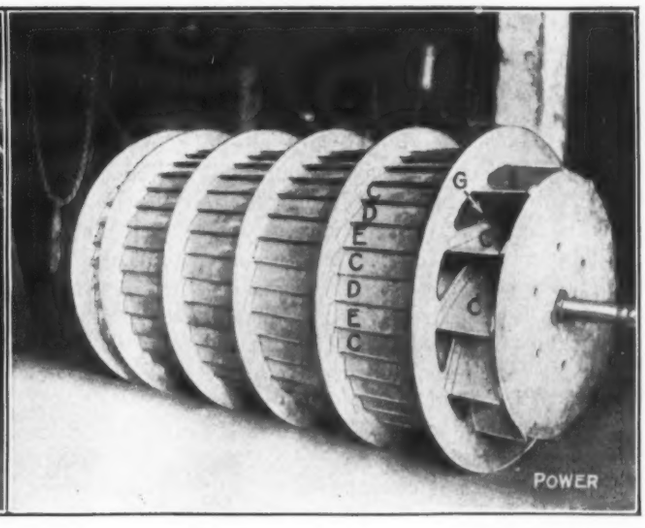


FIG. 4. SHOWING DESIGNS OF BAFFLE PLATES

Referring to Fig. 3, which shows the intake end of the revolving drum *A*, are holes used only in the construction and then covered. *B* shows the openings through which the air flows along a passage parallel with the shaft and formed by the tangentially arranged plates *C*, which are fastened to an inner, closed drum, to which the driving shaft is keyed. The outer edges of these air passages are protected by baffle-plates *D* and *E*, Fig. 4, the plates *C* being so bent as to throw the dust outwardly more readily. The separating rings *F*, Fig. 3, form, with the outer casing, separate compartments for the different grades of dust, but at the same time they project on the pressure side of the plates *C*, to form the pockets *G*, in which the dust is first caught and then thrown out of the revolving drum into the outer casing. As the pressure is above atmosphere inside the casing, the dust can be drawn off easily from this point in a concentrated form and easily removed.

Large machines work better than small ones, because with the increased diameter a corresponding increase in the length of the machine will allow a longer passage for the air. For example, air being delivered at one ounce pressure has a speed of about 80 ft. per second. A small machine of, say, 2 ft. in length would have to separate the dust, while the air was passing through the machine in one-fortieth second, whereas, exaggerating to make it clear, if the machine were 40 ft. long the air would stay in it one-half second. With an increased length and diameter, the number of passages also increase and, therefore, the capacity.

A separator of this type could be introduced between the boiler and the economizer and used to produce induced draft under the boilers, and at the same time clean the flue gases under pressure of perhaps several ounces of the economizers.

A further use of this type of machine is to ventilate engine rooms and at the same time provide a clean supply of air free from dust and maintain a higher pressure inside of the room, which prevents dust from being sucked in. The blower can also be used in supplying clean air for air-cooled transformers and for cooling turbo-generators.

Boiler-Feed Piping*

SYNOPSIS—The functions of an internal feed pipe and how to arrange it for best results. The only advantage in feeding a boiler through the blowoff is that it helps to keep the pipe from becoming plugged. A circulating pipe may be connected with a valve outside of the setting that will do the same thing. Stresses due to local chilling are as great as 10,000 lb. per sq.in., which is too close to the elastic limit of the material.

Internal Feed Arrangements

The purpose of an internal feed pipe, or any internal feed device, is to raise the temperature of the entering feed as nearly as possible to that of the contents of the boiler before discharging it, and, secondly, to direct the flow of the discharged water so that it will assist and not retard the natural circulation due to convection currents in the boiler. In addition to discharging the feed in the direction of the natural circulation, it is also necessary to prevent the entering water from striking directly on the heated shell plates or tubes, and particularly must this be avoided at the joints. Careful choice of layout for an internal feeding device will modify the deposition of scale and sediment.

The feed introduced at the bottom of the boiler, colder than the water inside, is, of course, always denser than the boiler water; it cannot rise with the natural circulation until it becomes so heated that its diminished density makes it rise. It follows then that the feed must spread out on the lower part of the boiler surface, displacing the hotter and lighter water, until it has taken up enough heat from the metal to rise naturally. The metal is certain to become appreciably cooled by this enforced heating of cold water, because the rate of heat transfer from the hot metal to the cold water depends on the temperature difference, and will be greater the colder the water. The cooling is assisted because it takes more heat to raise the temperature of a pound of water one degree than is given up by the cooling of a pound of steel through a like temperature range. Moreover, since the heating is so rapid, by far the greater portion of the heat given to the cold feed must come from the store of heat already in the metal, and not from that being transferred through the metal from without. Therefore, a cooling of the boiler metal through a considerable range at each entrance of fresh, cool feed water is to be anticipated.

Stresses Imposed by Cold Feed Water

It is well to consider the magnitude of the mechanical stresses involved when a boiler shell is locally cooled. Some years ago this subject was considered in *The Locomotive* (March, 1893), and calculations were made for the case of a steel boiler, working at 100 lb., into which feed water at 100 deg. F. was introduced. It was shown that under such conditions the plate would experience a drop in temperature of some 200 deg. F., and also that if the plate could be conceived of as being held rigidly at the edges by the unchilled portions of the boilers, stresses of 37,700 lb. per sq.in. might be developed in the chilled portions. This stress is great enough to seriously damage the plate, or even rupture the girth seams, but it is unlikely that so great a stress is produced, because the cooled portion of the plate is not held at its edges by an absolutely rigid structure, but is part of a shell which is elastic and yields under the pull of the cooled portion. Calculations which took account of this sort of action in the chilled boiler plate led to the conclusion that stresses of the order of 8000 to 10,000 lb. per sq.in. might be expected to occur in the particular boiler considered. This, of course, would be in addition to the pressure stress which a working boiler is always called upon to carry. A boiler plate, when stressed by the admission of cold feed water, must bear stresses quite too close to the elastic limit of the material for safety.

*Abstract from an article in "The Locomotive."

The internal feed pipe for preventing these stresses consists of a length of piping near the water line and of such length that the feed may be heated in traversing it very nearly to the boiler temperature. The discharge end is so located, depending on the type of boiler, as to direct the water flow away from the joints and the shell, and, so far as possible, with the natural circulation.

The various forms of steam-space feed depend on breaking up the incoming water into a spray or thin sheet so as to expose a large surface to contact with the steam. The effect is to condense enough of the steam to raise the water to boiler temperature while falling to the surface of the water already in the boiler.

Design of Internal Feed Pipe

The design of an internal feed pipe must vary with the type of boiler. In the horizontal-return tubular the best practice is to carry the pipe through the front head at the side and just above the top row of tubes. The pipe then extends back toward the rear head for about two-thirds or perhaps three-fourths of the tube length, running parallel with the tubes. At this point its direction is changed through ninety deg. by an elbow, and the pipe is carried across the boiler to a point near the opposite side where it terminates in an open elbow, which is arranged to face down. The pipe should be rigidly supported by straps from the braces so that there can be no chance of its rubbing on the tubes or plate when it pulsates under the intermittent action of the pump. If there is rubbing, a very rapid corrosive action will occur at the point of contact. The cause, often wrongly attributed to friction alone, is to be found in the displacement of rust or scale at each pulsation of the feed pipe so that fresh metal is constantly exposed to the corrosive action of the boiler water, so that a rapid attack is to be expected even from waters not otherwise especially corrosive.

In a vertical tubular boiler the internal feed pipe is usually fitted to discharge just below the water line, near the center of the tube nest. This arrangement, while quite satisfactory, has caused trouble, in at least one case, from the repeated contraction and expansion of the tubes directly exposed to the impingement of the entering water. This may perhaps be due to the fact that in this type of vessel, it is not easy to arrange an internal pipe long enough to serve as efficiently as in the horizontal tubular boiler. However, with the feed heated to a reasonable degree by some of the many forms of feedwater heaters, no trouble need ordinarily be anticipated. In very small vertical boilers, it is usual to introduce the feed water at a point near the bottom of the water leg, although this practice is not to be commended.

In locomotive-type boilers, wherever the construction makes it possible, an internal feed pipe as described for horizontal tubular boilers should be used. When this is impossible, the feed should be introduced in the barrel as far from the firebox as is feasible.

Where feed pipes pass through boiler shells or heads, we have found the best construction to consist of a boiler bushing of either brass or steel, threaded tightly into the head or shell plate, and with an internal thread into which the outside part of the feed pipe may be screwed on the outer end while the internal pipe is screwed into the inner end.

Two general considerations should always receive attention before a layout for an internal feeding device is approved. First, it is imperative that the internal piping be so arranged as to remain full of water, for, should it become in part steam bound, water-hammer is to be expected when the water flow is again established.

Secondly, the piping should be placed to be readily accessible for cleaning and repair, as the internal portion of a feed line is subject to incrustation or choking from scale, and when partially filled with such a deposit, it may not be able to supply feed fast enough to meet the conditions of maximum steam demand without permitting the water level in the boiler to become dangerously low. A choked feed pipe is especially dangerous in a plant where it is the practice to feed fast enough to meet the conditions of maximum steam demand without permitting the water level in the boiler to become too low. A choked feed pipe is especially dangerous in a plant where it is the practice to feed the boilers as much as they will stand without priming, and then let the level gradually drop to the lowest safe limit on peak loads, so that the firemen will not have to feed water when called upon for the greatest flow of steam. Under these quite too common conditions, if the feed pipe is not free and the pumps in good order, trouble is likely to be had in getting the water line back to a safe point if for any reason the heavy load should last longer than usual, or if the fireman should be careless and let the water go too low before starting to feed again.

Of the material for internal feed pipes, brass is to be preferred. Brass pipe will outlast iron in boilers fed with pure soft water, carrying some organic matter, and will have a life at least as long as iron in most boilers. Even more important, perhaps, than durability is the great freedom of brass pipe from choking. This is because no rust scale forms, and there is great difficulty which ordinary scale matter seems to experience in attaching itself to this material.

Feeding through the Blowoff

One reason why the practice of feeding through the blowoff has persisted so long is that it protects the blowoff pipe. Where a large amount of scale is deposited by the feed water, there is a tendency for sediment and scale to form in the blowoff pipe, and when this sediment becomes hardened and attached to the metal, overheating follows, since the blowoff passes through about the hottest part of the boiler setting. When there is a constant flow of feed water through this pipe, the sediment is kept well stirred and has much less chance to settle and bake on with disastrous results.

It is easy to arrange a circulating pipe connecting the shell, just below the water line, with the blowoff pipe and on the boiler side of the blowoff valve, which will accomplish all that the feed water can do in the way of keeping the blowoff free, and at the same time permit of feeding the boiler in the safer manner through a proper internal feed pipe. The vertical part of the connection, since it is outside of the setting and not covered, will radiate heat to the atmosphere fast enough to cool the column of water contained in it. This cooled water, as it is denser than the boiler water according to the difference in their temperatures, will flow down into the blowoff pipe, to be again heated by the hot gases, and thus as it rises again to the boiler a flow will be established which will be rapid and will be maintained automatically as long as the

boiler is under steam. A valve is fitted in this vertical pipe, near the tee where it joins the blowoff valve. This valve should be open at all times except when the boiler is being blown down, and it should be manipulated in a regular routine with the blowoff valves, so that the operator will acquire the habit of first closing the circulating valve.

In water-tube boilers, the same principles should be applied as in fire-tube boilers. The feed should not be introduced through mud drums or directly on the heating surface, but some form of internal feed pipe should be provided, adapted to the design of the boiler and which will be accessible, heat the feed water properly, direct its flow away from the heating surface and in line with the natural circulating current. This will usually be most easily accomplished by feeding in an upper or steam drum. Many excellent devices to do this have been designed by the builders of water-tube boilers, and many attempts have been made to combine with the feed-heating device some arrangement which will arrest and hold the sediment deposited by the entering feed when heated. They have only one objection; in the smaller drums usually associated with this type of boiler construction, it is rather difficult to so design an effective water-heating device which can at the same time act as a scale catcher, without seriously obstructing the spaces which must be visited by the inspector, and therefore rendering difficult the detection of incipient defects.

A single case exists where it is advisable to feed boilers through the blowoff connection. Where boilers are operated at low pressure for steam heating, and are fed with the condensed water returned from the radiating surface, then since the temperature differences are not great, both the circulation in the system and the return of the condensate will be facilitated by feeding through the blowoff.

Motors, Their Principles and Uses—IV

By Gordon Fox

SYNOPSIS—Considerations affecting the selection of motor installations, including group versus individual drive, type of motor, speed characteristics and voltage.

In order to gain the advantages of motor drive it is necessary that careful consideration be given to all the factors affecting a proposed installation. A mediocre installation may entail the same first cost as a first-class one, yet may include inefficient and ineffective drives and will not accomplish the result most to be desired, namely, the attainment of better manufacturing conditions.

Individual vs. Group Drive

The first factor for consideration deals with the degree of subdivision of units of power. It is possible, although not always advisable, to furnish an individual motor for each driven machine. On the other hand, entire plants, departments or divisions thereof may be driven by single motors through the intermediary of mechanical transmission systems. Each method has its points of value.

Correctly applied electric power affects production in three ways, namely, quantity of production, quality of product and cost of production. These factors in order will be discussed with reference to their bearing upon the method of drive selected.

Motor drive can increase the quantity of production from a given equipment due to maintained speeds at the machines, better shop layouts and more reliable service. Too much emphasis cannot be laid upon the importance of driving machines in such a manner as to gain the greatest output therefrom even though this be done with attendant increased cost for driving equipment and greater consumption of power. A few figures based upon average conditions will serve to illustrate this point. Assume that a five-horsepower motor is used for driving a machine upon which two men are dependent. The various items of factory cost are as follows:

	Cost per Day
Cost of drive, Interest, depreciation and maintenance on motor. 12% per annum on first cost	$0.04
Cost of power, 40% load factor, 10-hr. day. 2½c. per kw.-hr.	0.50
Cost of labor, Two men at $2.00 per day	4.00
Overhead cost, 1½ times labor cost	6.00
Total cost per day for this machine	$10.54

It is evident that it would be good economy to double the cost of power or to increase the first cost of the drive many times over if in this way the output could be increased.

The falling off of production due to slippage losses is seldom appreciated. With shaft drives it is practically always found that there is a drop in speed of the machines under load, varying from 5 to 15 per cent. The amount of slippage depends upon the distance of the machines from the source of power, the number of intermediary countershafts, the ratio of pulley diameters, belt sizes and speeds and the condition of the belts. It is likely to be greatest for high-speed machines requiring the use of small pulleys and for very slow-speed machines requiring the use of low belt speeds. The relation of production to speed may or may not be in direct proportion. Where materials or tools are automatically or power fed, it is usually found that production is proportional to speed within certain limits.

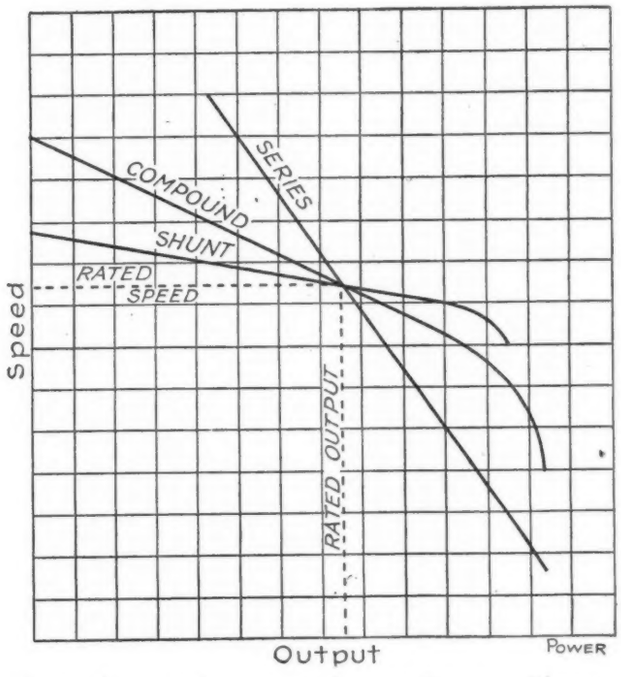
Individual drive is well suited to that class of machines which require variation in speed. Such machines may be divided into three classes; those whose speed is under constant manual control, those requiring frequent adjustment and those operating comparatively long periods at given speeds. The first two classes may be independently driven most effectively; for machines of the third class, adjustable-speed motors may be provided, although constant-speed motors with mechanical speed-changing devices will sometimes suffice and may have lower first cost.

There are many hand-fed tools in which production is not increased directly with maintained speeds. Where the rate af handling material is the limiting feature the possibility of increasing production is lessened. In some cases the methods of handling can be improved so that the operating intervals are closer. It is true of most machines, however, that they perform their work more quickly at maximum speeds. This general statement follows: *Hand-fed machines, continuously operated, in which the productive processes consume a large percentage of the total time and the rates of performance of which are proportional to the speed should, in general, be individually driven.*

From the point of view of maintained speed only the following machines warrant group drive:

Small constant-speed machines, hand or power fed, which are too light to cause material slippage.

Machines intermittently operated, where the saving does not compensate for the extra cost.



SPEED-OUTPUT CURVES FOR DIRECT-CURRENT MOTORS

Hand-fed machines where handling of the material must consume a large proportion of the time.

The second manner in which the method of drive affects production is in the shop layout. A close study should be made of the proper sequence of processes to reduce handling and machining of waste material and to gain the final result in the shortest total time. The product should be made to move as far as possible in one general direction. It is impossible to estimate the exact cost-decreasing value of a given layout but, in general, it may be stated that subdivision of power units should be carried out as far as there is any advantage whatsoever in the arrangement allowing better handling of material between tools. From the point of view of shop layout, *individual drive is usually warranted for heavy-duty machines.*

The third manner in which motor drive may be made to increase the quantity of product is through more reliable service. There are only a few machines that warrant the use of individual motors for this cause alone. It is frequently found that there are two or three machines through which the entire factory product passes or upon which whole departments rely for their material. For such machines individual drive is usually warranted.

The quality of the product may be bettered by motor drive, directly through uniform speeds and upkeep of machinery and indirectly through better manufacturing conditions. Direct-connected machines will remain in good condition longer than belted machines due to decreased bearing wear. Also subdivision of power units decreases the amount of overhead belting and shafting, allowing better illumination and ventilation.

While power costs are usually lower where individual motor drives are employed, it must be understood, however, that the substitution of a motor for some other source of power in a plant may not necessarily lower the power cost. A reduction in this item may be obtained by lowering the cost of generation or purchase, lessening the losses of transmission, and decreasing wasted consumption. The latter can be obtained only by applying the motors most effectively either individually or in small groups. Where individual drive requires the use of a number of very small motors, the lower efficiencies may counteract the advantage of subdivision. Also machines widely scattered usually incur large transmission losses, and where the length of shafting per horsepower used is large the losses will be heavy.

The great difference between mechanical drive and individual motor drive in the matter of power consumption is that the losses with motor drive are roughly proportional to the load delivered whereas with mechanical drive there is a fairly constant loss regardless of the load. In view of this, if the cost of power is a considerable item, the use of small power units may be justified. Moreover, independent motors should be installed for driving such machines as will be required to operate overtime.

Regarding overhead cost, the point is often raised that it is necessary to install a greater total horsepower in motors for individual than for group drive. This is generally true but in a modified degree. Motors driving groups must not only be of sufficient capacity to meet the power demand of the machines but must supply transmission losses also. This contention depends largely upon the diversity factor. If the ratio of average load to connected demand is low the group motor may be relatively small. This feature plays an important part in determining comparative first costs. A number of intermittently operating machines which are not simultaneously used can be group driven with low first cost and good efficiency. A related condition exists where machines require heavy instantaneous peaks or starting loads. Individual motors must necessarily be of sufficient size to carry these overloads. If such machines are grouped, the peaks are smaller in proportion to the capacity of the single-group motor. This motor may then be much smaller than the connected capacity with individual drive.

In some cases the driven machines may form natural groups where several interdependent operations are performed on machines closely related. For instance, the operation of a brick machine requires simultaneous driving of conveyors and cutting table. Groups of this character are often best considered as a unit.

In summarizing, it may be stated that individual drives are best suited for machines continuously operated whose

production is directly or largely dependent upon maintained speed, for adjustable-speed work where ready control is desirable, for most heavy machinery, and where necessary for most effective location. Group drive is best suited to natural groups, for driving numbers of light machines, for driving machines intermittently operated and not simultaneously used and wherever the advantages of individual drive are insufficient to warrant the extra cost.

Types of Motors

The relative value of alternating and direct current for industrial power service is a matter receiving considerable discussion. The inevitable conclusion remains that each system has specific points of superiority adapting it to particular fields. There are several types of alternating-current motors having a fair range of characteristics; yet there are several types of direct-current motors affording another possibly wider variety of characteristics. Certain results can be paralleled in either class; other results can be attained in one class only.

Where power is purchased the type of motor installed is usually dictated by the current available, although this is not always warranted. The use of a motor-generator set for conversion may incur a greater first cost and a slight loss of power. The cost of power, however, is often only a small percentage of the total factory cost, and if manufacturing efficiency can be better secured with a given type of motor that type should be installed. The economies obtained will ordinarily more than repay the slight increased cost for equipment or power.

The advantage of the alternating-current induction motor is simplicity; its great disadvantage is inflexibility of speed. It is essentially a constant-speed machine having a few fixed speeds and as the majority of drives require constant speed the field for this motor is large. For this service its reliability, low maintenance cost and general ruggedness are strong recommendations. The first cost is lower than that of the direct-current motor, although the cost for wiring is somewhat greater; its efficiency is comparable with that of the direct-current motor except for the lower speeds, and it is lighter. It has no commutator and usually no brushes, and has good starting torque which is accompanied, however, with a rather heavy rush of current. Its pull out or stalling torque is liberal and it does not succumb to the effects of overloads as quickly as does the direct-current motor. Its characteristics parallel closely those of the direct-current shunt motor and it can be adapted successfully to most applications for which that type is suited. A disadvantage peculiar to the induction motor is low power factor under fractional loads requiring liberal provisions in generating equipment.

Induction motors may be used for certain classes of variable-speed work; this range is limited, however. The multispeed motor affords three or four rather widely separated running speeds without intermediate control. The slip-ring motor permits of graded control over a limited range only. It parallels the direct-current motor with armature control having a fluctuating speed dependent upon the load. This fact makes it unsuited for machine-tool work. It finds some application for blowers, pumps, printing presses and the like where the torque is fairly uniform.

The synchronous alternating-current motor has few advantages for industrial service from the point of view of the driven machine. It has low starting torque, constant speed over its entire range, a high first cost, requires an exciter and usually a switch panel and demands intelligent attention. Its use is justified, largely because of electrical considerations, as a synchronous condenser to counteract the power factor effects of a number of partly loaded induction motors.

Single-phase motors are largely confined to small sizes upon central-station circuits for minor installations. They are seldom used extensively in industrial service.

The direct-current simple shunt motor is a constant-speed machine. It exerts a fair starting torque and moderate overload torque. The compound-wound motor has a less constant speed but can exert a heavy starting torque with low current input and has a liberal overload capacity. Its performance can be approached but not duplicated by the induction motor with high rotor resistance. The series motor exerts heavy starting and overload torques and its speed varies widely with the load. Its performance cannot be duplicated by the induction motor. Shunt or compound-wound motors may have their speeds externally controlled over a wide range, the speed remaining approximately constant at any point. This result cannot be attained by any type of alternating-current motor.

The advantages of direct-current motors are: flexibility and freedom from limitation in speed, wide range of torque characteristics, ease of speed control, simplicity of wiring and control devices, adaptability to remote control, quick acceleration, low starting current, wide air gap, freedom from power factor effects and ease of dynamic braking. The great disadvantage lies in the presence of a commutator and brushes, decreasing reliability and ruggedness and increasing maintenance costs. In general, it may be stated that the direct-current motor is superior in electrical characteristics and the induction motor in mechanical features.

Choice of Voltage

Where direct current is used, 220-volt service is nearly always suitable and is almost standard. The use of 550 volts may be necessary due to local considerations such as for car shops, etc., but its general use is to be discouraged due to increased maintenance expense. The use of 110 volts requires considerable expenditure in copper for the wiring system with little gain in reliability Illumination requirements may occasionally dictate its use.

For alternating-current work 220 and 440 volts are the most common, the latter being preferable where large motors are used due to decreased cost of wiring. At present, 2200-volt motors are not extensively used in factories due to increased risk, higher first cost of the motors and wiring and somewhat greater liability to trouble.

The choice of frequency is generally of less importance. Sixty-cycle motors allow higher speeds and a greater choice, which may be a distinct advantage in some cases. On the other hand, 25-cycle motors can be obtained for slow speeds with better power factors. Sixty-cycle motors are lighter in weight and lower in first cost. Twenty-five-cycle current is not satisfactory for illumination with arc lamps.

There is little advantage in the three-phase system over the two-phase system although three-phase motors show slightly higher efficiency and the cost of wiring is lower.

Following are some items which should receive consideration when deciding upon the details of any motor installation:

Running speed and torque characteristics.

Is the load steady or fluctuating? What is the cycle of changes?

Is the load continuous or intermittent?

Is constant torque or constant horsepower required?

What starting torque is required? Is it the same for all positions?

Is frequent starting necessary?

What are the limiting features of the load?

Can the motor best be direct connected, belted, geared or chain driven?

Is the motor near a source of heat or subject to dirt, iron chips, injurious fumes, gases or moisture?

What fire and explosion risks occur?

What is the intelligence of the operators?

Is the motor to be in position for good ventilation and accessible for repairs?

What is the best method of control and most convenient location of control equipment?

Should fuses, overload release or time-limit devices be used for protection?

What will be the effect upon the source of power?

Size of Motor

The size of motor selected for a given work depends upon the average load, the maximum load and the starting requirements. The horsepower ratings of motors are based upon temperature rise. A 10-hp. motor is not limited to a 10-hp. load. It might deliver 20 hp. for very short periods, if during other periods it delivers less than 10 hp. In the majority of cases, the motor size should be determined by the average load, not the maximum. Particularly in alternating-current work it is undesirable to install larger motors than necessary, as they operate at lower efficiency and power factor on partial loads.

The starting torque of a machine may be determined by mechanical measurement, a rope being attached to the belt or passed around the driving wheel, and sufficient pull exerted to start the machine in motion; this pull is measured by means of a spring dynamometer. The radius of the wheel being known, the torque in foot-pounds may be directly calculated. If preferable, a lever may be attached to the driven wheel and weights added at a given radius until the machine is started. The torque may be estimated from this data, including the weight of the lever at its middle point.

The relations of load, torque and speed should be considered in determining the type of motor best adapted to a given work. The accompanying curves show the relative load-speed characteristics of shunt, series and compound-wound motors. The speed of a series motor is shown to be excessive when running under no load, but falls off rapidly as the load is increased. The shunt motor, on the other hand, has a no-load speed not much greater than that at full load, the decrease in speed being comparatively slight with increase of load. Again, the compound-wound motor is seen to have a characteristic lying between those of the shunt and series motors. Consideration of these curves will show that the shunt motor is adapted to driving machines which require a starting torque not greatly in excess of full-load torque and requiring practically constant speed. The series motor evidently will have an advantage where high starting torque is required and speed variation is not an important factor, or where the character of the load prevents excessive speed variation. The compound-wound motor will meet the requirements more specifically where the starting demand is greater than that which can be met by the shunt motor and where at the same time it is desirable to maintain fairly constant speed over a considerable range of load.

The squirrel-cage induction motor is generally used for work similar to that for which the shunt-wound direct-current motor is fitted. The squirrel-cage motor with high resistance rotor approaches in characteristics the compound-wound motor. The slip-ring motor is similar to the compound motor with a large percentage of compounding. This is the nearest approach obtainable to the direct-current series motor.

Special care is required in selecting series motors because their speed varies widely with the load. In order to provide for a definite running speed, it is necessary that the exact load be known. A series motor is rated at its full load speed, and if the load be greater or less, the speed will be lower or higher, respectively. Series motors are not generally suited for belt drives, since if the belt should be removed the motor would race and might destroy itself. They should be positively connected to the driven machine through couplings, chains or gears.

Adjustable speed requirements cover a varied set of conditions not easily differentiated. The more common types of variable-speed service and the usual methods of driving them may best be shown in tabulated form.

In direct-connected applications, the speed of the motor is closely fixed; for gear and chain drives there is often some choice. In such cases, the motor speeds should be as high as good mechanical conditions permit due to lower first cost, and, for induction motors, better efficiency For belt drives, there is usually considerable range for selection in motor speeds. High-speed motors often necessitate small pulleys and wide belts. It is well to figure the total cost of two or three possible arrangements, including the cost of motor, belt and pulleys. If there is no choice from a mechanical standpoint, that arrangement having the lowest first cost should be selected. In this connection, the relation of belt speed to cost of belt maintenance should not be overlooked. Other things being equal, the preference should be given to high-speed induction motors and moderate-speed direct-current motors. An attempt should be made to restrict the number of different ratings where this can be done without sacrificing the drive. There is considerable advantage in duplication of machines due to interchangeability and ease with which repair parts may be provided.

Aside from speed and torque considerations, efficiency and power factor should receive attention. It is false economy to install an inefficient motor because of slightly lower first cost, and to lose in operating costs many times the margin saved. The importance of this depends, of course, upon the unit cost of power and the motor load factors. It must be remembered, however, that the bill for a motor is paid once, that for power many times over.

The effect of low power factor is to cause increased losses in distribution and equipment, and to affect the voltage regulation of transformers and generating ap-

paratus. Its importance to the user is greater where isolated plants are installed. If a number of small motors, operating on partial loads, are connected to the lines, difficulty may be experienced in maintaining the voltage and liberal generator and exciter capacity is required. Tirrill regulators are useful in this connection, but cannot entirely overcome the difficulties.

Mechanical Considerations

Some of the mechanical considerations affecting motor selection may be briefly enumerated. Weight alone is not a good basis for comparison, as some motors contain large amounts of inactive material. General dimensions and workmanship throughout are the best indications. The design should permit accessibility and provide for free ventilation and radiation. The frame should be rigid, with low center of gravity and widespread feet. The bearing flanges should allow access to the interior, should shield the windings and should form rigid bearing supports. The bearings should be liberal. Phosphor bronze is not desirable for large sizes, due to its tendency to freeze tight when heated, causing possible injury to the shaft. A liberal air gap is desirable in direct-current motors for electrical as well as mechanical reasons. A wide air gap in induction motors is usually accompanied by low power factors. A reasonable clearance is desirable, with provision for taking up wear in the larger sizes where wear is more rapid. Heavy shafts are advantageous for maintaining alignment and withstanding strains, and for distributing bearing wear. Insulating methods are of great importance, and measurements of dielectric strength and insulation resistance are useful.

The quality and finish of accessories, such as control equipment and base or rails, should bear consideration. However, it is better to simply specify performance and to consider the details of the equipment proposed rather than to try to bind the manufacturers to specifications which will likely conflict with their standard methods.

SOME MOTOR APPLICATIONS

Class of Service	Typical Example	Type of Motor and Method of Control Direct Current	Alternating Current
Wide range of operating speeds to be approximately constant at any point.	Machine Tools.	Shunt interpole motor with field control.	Not attainable electrically. Use mechanical change devices. Multispeed motors for special cases usually of constant-horsepower type.
Moderate speed range. Decreased speeds corresponding to decreased loads. Uniform torque.	Fans, Blowers, Pumps.	Shunt or compound motor. Armature control, or combined field and armature control.	Slip-ring motor with suitable external resistance.
Small range of operating speeds near normal. Decreased speed for short intervals.	Printing Presses.	Shunt or compound motor with combined field and armature control.	Slip-ring motor with suitable external resistance. Multispeed motors in special cases, usually of constant-torque type
Continuous manual control.	Elevators, Cranes, Hoists.	Compound or series motor. Armature control.	Slip-ring motor with suitable external resistance.

Chain-Grate Settings--I*

By Osborn Monnett†

SYNOPSIS—Horizontal vs. vertical baffles for water-tube boilers, and a comparison of flat and sprung arches.

In taking up the application of mechanical stokers to water-tube boilers, one of the most important types and alphabetically first is the chain grate. When properly installed, it is an excellent stoker for smoke suppression. There is no cleaning period which is the bugaboo of a great many mechanical stokers, and in other respects the human element is reduced to a minimum.

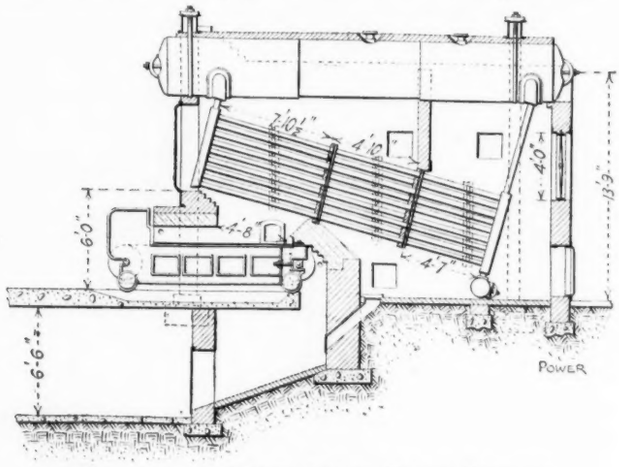


Fig. 1. Old Type Chain-Grate Setting

The first question naturally arising is the choice of baffling. There is a great deal to be said on this subject,

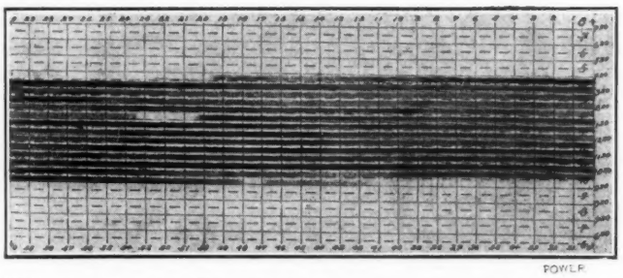


Fig. 2. Smoke Chart of Setting Shown in Fig. 1

but in general it may be stated that the horizontal baffle is much safer from the smoke standpoint. Elaborate tests have been made to determine the effect of horizontal baffles on the capacity and efficiency of a boiler, as many engineers are prejudiced against the horizontal baffle on account of the fear that there will be a falling off in one or the other of these items.

A striking illustration of the effect on smoke production with a 350-hp. horizontally baffled boiler and the same boiler vertically baffled can be seen in Figs. 1 to 4. Fig. 1 shows the boiler with the old-style chain-grate setting, with a head room of 6 ft. under the front header. Fig. 2 shows the smoke performance of the setting. The boiler was then raised 2 ft., giving 8 ft. under the front header, and horizontal baffles giving a single pass for the gases were put in, Fig. 3. The smoke record after the change is shown in Fig. 4. The original installation gave an evaporation at 212 deg. of 6.05 lb. of water per pound of coal as fired. After the change, the evaporation was 5.96 lb. of water. In both tests, coal of 8902 B.t.u. per lb. as fired was burned.

†Smoke inspector, city of Chicago.

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From test data available, it can be definitely stated that the difference in efficiency between well set vertically baffled and horizontally baffled boilers working within commercial limits and with both boilers in equally good condition inside and out, is negligible. It is usual to realize an efficiency of 65 to 68 per cent. with either type of baffling under good operating conditions when using a low-grade Illinois screening.

Working under normal capacities, the horizontally baffled boiler does not suffer appreciably over the vertically baffled boiler. When driven to capacities up to 175 per cent. of rating, the single-deck horizontally baffled boiler will show a dropping off in capacity of 10 or 12 per cent. over the other type of setting. For the ordinary industrial boiler plant, the difference in either capacity or efficiency can be neglected where the boiler is not run at a rating higher than 50 per cent. overload.

There are other points to be considered, however, before deciding on the gas passes. It must be admitted that the horizontal baffle on boilers having the B. & W. tube spacing costs more to install, costs more for maintenance, and, owing to the tendency for pockets of soot

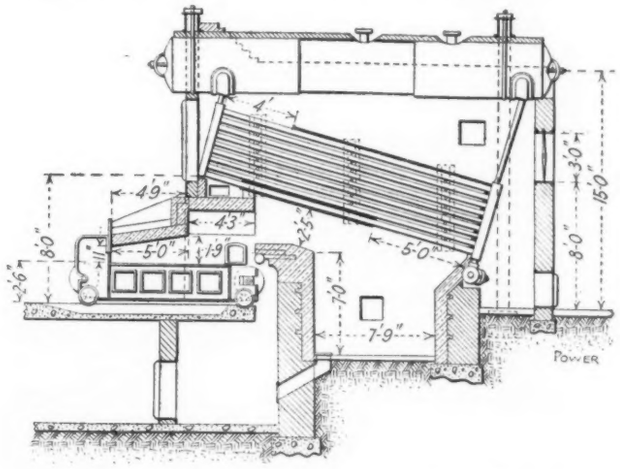


FIG. 3. IMPROVED SETTING FOR SAME BOILER

to form on the baffles, must be watched more closely in operation to obtain capacity and efficiency. The character of the attendance then is a feature, and the draft loss through the setting is generally greater.

The selection of a horizontally baffled boiler may be made through limited head room or where the smoke question is of prime importance. There are certain industries where horizontally baffled water-tube boilers will produce less smoke, as in connection with a chain-grate stoker it is about as "foolproof" as anything that can be designed to run smokelessly. It is an ideal equipment for a plant where labor conditions are liable to be a factor; where many changes are made in the operating force, or where there is a strong probability of unskilled attendants. Also, such an installation is ideal for a steel works, a packing house, railroad shop or any industry where men work on 12-hr. shifts. With so long a watch, carelessness is apt to creep into their work. On the other hand, if accumulations of soot are allowed to collect on the heating surface, then this type of setting will not compare favorably with a vertically baffled boiler.

Another question arising with chain grates is the choice of flat or sprung arches. Many engineers will not put in a flat arch owing to the fact that in the past they have been installed improperly for the work they were

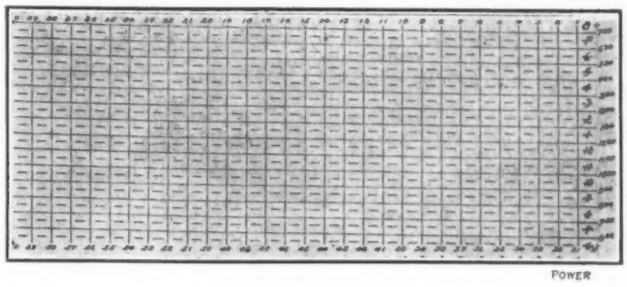


FIG. 4. SMOKE CHART FROM SETTING SHOWN IN FIG. 3

designed to do. With the sprung arch, the cubical contents over the fire is greater. For this reason, the gases are not restricted and pass away rapidly from the furnace. The ordinary sprung arch is generally set level, with the skew-backs about 9 in. above the grate, and the highest point of the spring 18 in.

On the other hand, the flat arch is somewhat cheaper to install, cheaper to maintain, puts less stress on the side walls, and in many ways has constructional advantages over the sprung arch. The latter must be taken out of service immediately when it commences to deteriorate, owing to the danger of complete and sudden failure, whereas a flat arch, with each element suspended independently, can run along indefinitely until it is convenient to take the boiler out of service. The ordinary flat arch of a few years ago was set too low at the gate and was too short for high capacities. The practice was to set the arch 11 in. above the grate at the gate and about 22 in. at the inner end, with a length of about 3½ or 4 ft. This was not enough arch to give a good igniting effect; the clearance between the arch and the fuel at the gate was too small to take care of the thick fires and heavy overloads sometimes encountered.

When installing flat arches, it is now common to raise them higher above the grate to give a generous volume into which the volatile matter may expand. Their length has also been increased. The minimum length of arch for any chain grate should be not less than 5 ft., and wherever necessary to get the proper furnace design it may be longer. This has resulted in a substantial increase in the capacity of furnaces equipped with flat arches.

Temporary Rheostat Repairs

It frequently happens that starting or field-control rheostats become open-circuited, due to the burning out of a coil at a time when it is impracticable to remove them from the circuit for repairing.

In these emergency cases a temporary repair can be made by ringing out the rheostat (button by button) with a magneto until the break is found, and then filling the gap between the two buttons at the break with solder, filing the surface off flush with the contact buttons.

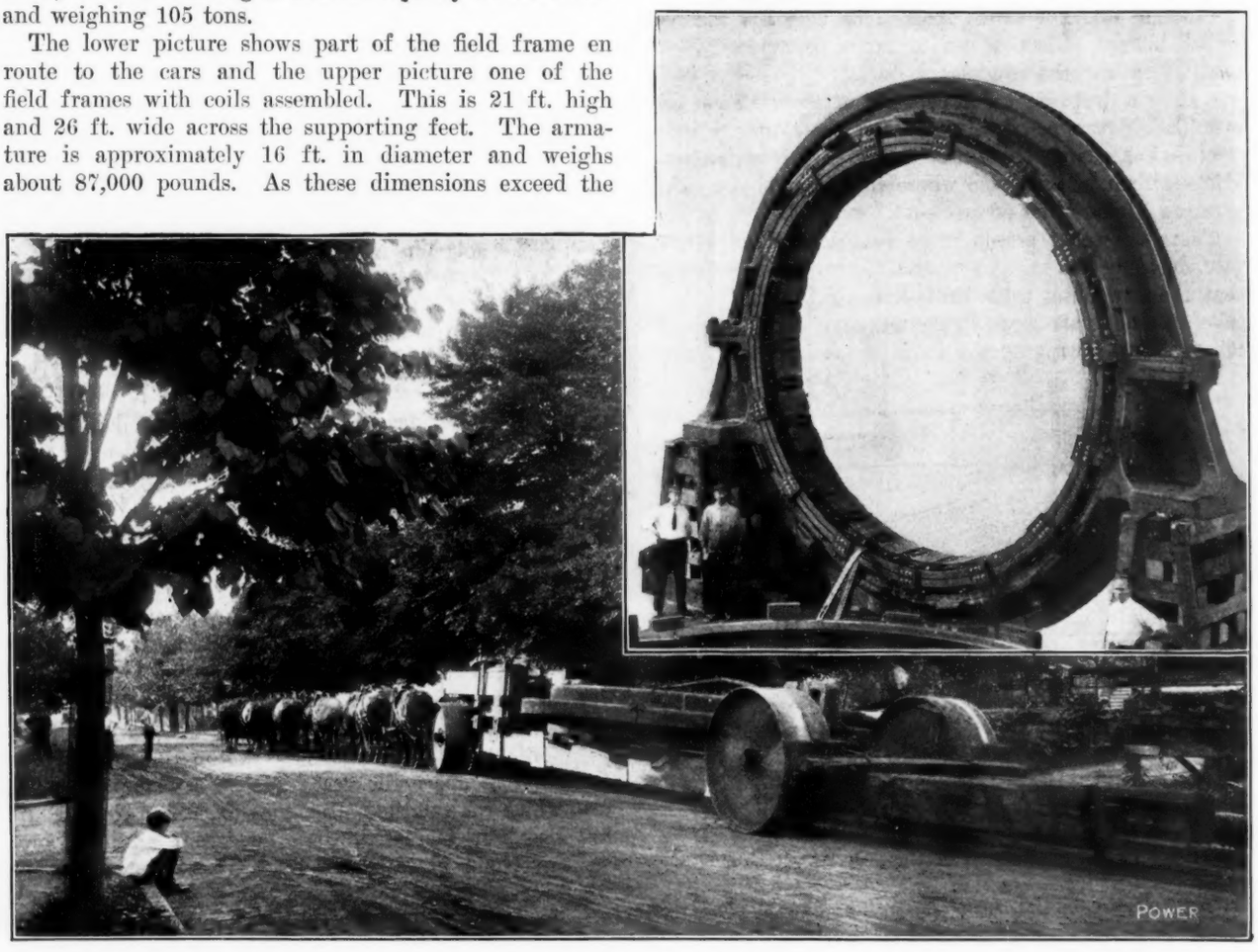
As to starting rheostats, cutting out the defective coil may make the starting a little uneven, and because of this the rheostat arm should be brought up somewhat slower than ordinarily. The only effect on the operation of field-control rheostats is slight resistance decrease.

In cases of extreme emergency, it is possible to keep a defective rheostat in service for some time by wedging a piece of fuse wire or forcing a nail in the gap between the defective contact buttons.

Handling of Large Direct-Current Generators

The first car containing generator parts for the mammoth direct-current power plant of the Ford Motor Co. recently left the works of the Crocker-Wheeler Co. at Ampere, N. J. It will require about fifteen cars to transport all the material which comprises these four big units, each one having a normal capacity of 3750 kw. and weighing 105 tons.

The lower picture shows part of the field frame en route to the cars and the upper picture one of the field frames with coils assembled. This is 21 ft. high and 26 ft. wide across the supporting feet. The armature is approximately 16 ft. in diameter and weighs about 87,000 pounds. As these dimensions exceed the limits set by the railroads for clearances on tracks, bridges and tunnels, the assembly of the armature parts and winding will be done in Detroit.



UPPER VIEW: STATOR WITH FIELD COILS IN PLACE. LOWER VIEW: PART OF STATOR BEING TRANSPORTED FROM SHOPS

Some Alaska Boilers Described

BY EDWARD M. KEYS, JR.

Being in need of a small boiler at the mine here in Alaska, I searched the country for a second-hand one. I found many in a dangerous condition and naturally did not make friends by saying so.

One 10-hp. upright had been allowed to fill with mud around the side of the firebox, and became overheated and bulged between the stays until the metal was only a scant ⅛ in. thick. Mud had also collected on the lower tube sheet and pockets had formed. The owner stated that it had carried 180-lb. pressure without exploding, and he knew it was safe!

A machinery firm had one for sale which did not look good, and the manager, when it was suggested that he knew very well that the boiler would never stand marine inspection, replied, "In marine work they cannot afford to take chances."

The next examined was a locomotive-type boiler, but one peep at the crown sheet was enough.

At another place a man was just firing up a little upright, and while asking him a few questions regarding any boilers of which he might know, I noticed that he started the injector with no pressure registering on the steam gage. I asked him if the gage was not out of adjustment. "Oh, she's only got 60 lb. of blind steam," he replied, and explained that he meant by "blind steam," the pressure not recorded by the gage.

At another place a 60-hp. boiler had only a 1-in. pop safety valve and that had a stop valve between it and the boiler.

A boilermaker, taking the tubes out of a 40-hp. return-tubular boiler, told me to look inside. Mud had accumulated on the tubes, and was packed solid between them in some places. The crown-sheet had an inch of mud on it. Two new handholes had to be cut in the sides to get the mud out of the water legs and the sheets had nearly pulled off the stay-bolts.

Surely, we need an inspection law here, where boilers of from five to three hundred horsepower are being operated by inexperienced men.

Editorials

Detecting Lap Cracks

One of the principal causes of disastrous boiler explosions is the lap-seam crack. Considering the present agitation for "safety first" and the evident demand for laws to govern the construction and operation of steam boilers, with the idea of reducing the loss of life and the destruction of property occasioned by boiler explosions, it would seem logical for the law makers to take some surer means to eliminate this cause.

True, practically all modern boiler laws recognize the danger in this form of construction and prohibit its use in new boilers; while such laws will ultimately do away with lap-seam boilers, it is not practical to require owners of lap-seam boilers to discard them for more modern construction. While the butt-strapped construction is more widely used today than a few years ago, there are, no doubt, several times as many lap-seam boilers constructed now as there are butted and strapped type. These boilers must be operated for years yet, and while the laws in force have tried to curtail their use, by prescribing high factors of safety, this remedy is little better than condemning them outright.

Another objection to increasing the factor of safety is, that it has never been conclusively demonstrated that the factor of safety has had any bearing on the subject, for boilers that have been operating at very moderate pressure seem to explode as readily from this cause as those operating at higher pressures. The difficulty has been that the lap-seam crack defies detection until it has weakened the structure so much that an explosion is almost inevitable. A number of ways have been suggested for detecting these defects, such as testing the electrical resistance of the plate across the part that was supposed to be affected, and taking X-ray pictures, with apparatus strong enough to show the cracks in the plate if they should exist, but none of these seemed to be practical and were never tried. Recently a process has been proposed for this purpose, that is so simple that it would seem impossible for it to fail to detect such cracks if they exist in a boiler to which it is applied. This method was explained in the July 14 issue of POWER, on page 56.

Since lap-seam boilers cannot well be exterminated at once, it would seem proper for the law makers to require that all owners of them provide this simple means of determining whether they are sound or not.

After a recent explosion produced by a lap crack, the mating boiler, of the same make and age, was suspected of having the same defect, although no external evidence revealed it. Cutting the seams as described in the article referred to above, showed the presence of dangerous cracks and use of the boiler was abandoned. If this test had not been applied, likely this boiler would have been placed in service and it might have later exploded and caused as much loss of life and destruction of property, as did its mate.

In another instance two boilers were suspected of containing lap cracks, because the mating boilers of the battery had developed such cracks several years before which fortunately were discovered before they resulted in an explosion. The inspector was disturbed about these boilers and had told the owners of his fears, but had to admit that his apprehensions were grounded on conjecture only and that he had no positive knowledge that there was anything the matter with the boilers. However, when the detector slots were placed on the seams, it was conclusively shown that very dangerous cracks existed in the plate and use of the boilers was discontinued at once. In numerous other instances this test has shown that suspected boilers were perfectly sound and could be safely continued in use so far as danger of an explosion from a lap crack was concerned.

It is proposed by some to discard lap-seam boilers after a given number of years' service, but this would be an uncertain remedy, for explosions from this cause have been known to occur with boilers only three years old, while others are twenty years old before showing the same defects. Usually lap-seam cracks appear in from ten to fifteen years. The method of detecting the lap-seam crack, here referred to, is practically the same principle as the drilling of the ends of staybolts to determine when they break. If as many explosions resulted from the breaking of staybolts, as from the formation of the lap crack, there is little doubt but that the drilling of the ends of the bolts to detect such defects would be compulsory.

Oil-Engine Outlook

Probably the only important factors now to limit the growth of the internal-combustion industry in America, particularly the oil engine, are the cost of the fuel employed, capacity feasible in a single unit and human conservatism. Due to the better knowledge and greater experience of the manufacturers, the foundation for the old prejudice against this form of prime mover because of its unreliability has been largely swept away. The hackneyed charge that America could not produce the class of workmanship found in Europe is now refuted in this and other fields. The manufacturers have been brought to the realization, when not so possessed at the outset, that not only must suitable material and high-grade workmanship be alleged but must actually be employed.

In the general power field, producer-gas installations and heavy oil engines must compete with steam-driven prime movers and with each other. In some cases geographical location may clearly require or local conditions may indicate a given type, but in general, operating costs and personal preference will govern the selection. A few years ago the gas-producer plant seemed to be the "runner up" of the small steam installation from the standpoint of economy, but the oil engine seems now to have supplanted it in the contest.

It is often hard to overcome the hesitancy of man to try the untried, notwithstanding the weight of reason,

even in his own mind, may be against his attitude. This is indicated by the fact that there are people doing business who have not adopted the typewriter or the telephone, although they know, or should know, that to do so would be to their advantage.

The basic Diesel patents having lapsed, the heavy-oil-engine industry has received an impetus by the entrance into the field of many well established and equipped concerns, which presages progress in this line.

He Weighted the Safety Valve

The safety valve on a boiler at the Thornhill Iron & Steel Works, at Dewsbury, England, persisted in blowing. Thinking that this was due to the valve not being tight, the engineer of the works instructed an attendant to hang a weight on the lever. He thereupon put on a fifty-pound weight. This failing to stop the escape of steam, the engineer instructed him to put on another, which he did, this time of over sixty pounds with about ten pounds of hooks, etc., whereupon the boiler exploded, causing the death of seven men and serious injuries to over twenty others. There are lots of men in charge of boilers who do not know any better. Is it time for an inspection and license law?

Reading in the Engine Room

One says that the engine room is no place to read; another that a good engineer will find something else to do rather than read. Numerous similar objections may be made to the practice. While we are not arguing that the engine room should be made a reading room, we can see no reason why a good engineer should be constantly on his feet or tinkering with something or other. Then, if he has a place where he can keep his eye on everything, certainly there is no harm in his sitting down and reading.

This applies particularly to the night engineer. He has a long, lonesome watch, with a light load and more leisure. Why should he not improve the time reading up on matters that will make him a better engineer. He has no time to read at home for when he is not trying to sleep he owes it to his wife and children to give them a little attention. When he has everything running smoothly at night, he can do a little reading without neglecting his duty in any sense. Who could criticize him if he made himself comfortable and dug into such questions as economical combustion, methods of analyzing coal, economizer losses due to scale, or any other subjects relating to power-plant operation and repairs?

The Night Engineer Off Duty

Speaking of the night engineer, have you never been one, or if you have, was it so long ago you have forgotten his hardship? If he is the average one, he has twelve hours on duty. Arriving home his wife is up to greet him and his youngsters too, if he has any. Then he has breakfast with them. After he eats he visits with them a little time, if he is not too dead tired, and then he goes to bed.

Meantime the noise and bustle increase out on the street and the night engineer is trying to sleep.

The sun grows hotter and hotter until his bedroom feels like the inside of a boiler off for cleaning, with a leaky stop valve; sleep is out of the question and the poor man gets up in the afternoon with probably no more than three or four hours sleep out of his twelve hours off. He must give his family some of his waking time before he goes back to the plant. Perhaps he has some errands to do, or a few odd jobs around the house. Then off he goes for another night's turn. This rather tedious cycle is repeated every twenty-four hours. Is it any wonder that one occasionally falls asleep on duty?

We must have a little charity for the night engineer.

Investigate Boiler Explosions

There is one thing that the law which the committee of the American Society of Mechanical Engineers is to recommend as a model for legislation to restrict the slaughter and damage occasioned by the abuse of boilers and other pressure vessels, should include. It should provide for a thorough investigation as to the cause of every serious accident to a boiler or to the sort of pressure vessel the use of which it is intended to regulate.

The Board of Boiler Rules, or some other competent body, should be authorized to carry out this examination, empowered to subpœna witnesses, to call for books, papers and other pertinent evidence, and be required to submit a report within a reasonable time to the governor, showing the cause and manner of the explosion, and fixing the responsibility. The owner and operator of a plant in which an explosion occurs should be required to immediately report the same to the investigating authorities, and penalties be provided for a failure to do so. Insurance companies should also be required to report claims for losses. In this way, a vast amount of valuable and authentic information regarding explosions would be accumulated, stress thrown upon the causes which most frequently produce explosions, and a way pointed out to avoid them.

Engineers' Study Course

With lesson XXX, which appears in this issue, the section of the Study Course on Elementary Mechanics is concluded. To the man working in the power plant who is desirous of knowing a little more of the theory of the machines, this course should be of value and help. He will find many cases where he can apply the more general laws discussed in the course to the solution of some particular problem that may confront him.

Many more and useful principles of mechanics might have been discussed but owing to the desire to avoid all complicated mathematics these have been omitted, especially the mechanics of liquids and gases.

It is hoped that all the readers of POWER who have followed these lessons in mechanics may have gained some new insight into their various lines of work, and have had aroused in them a keen desire to know more about the "whys and wherefores" of their particular business.

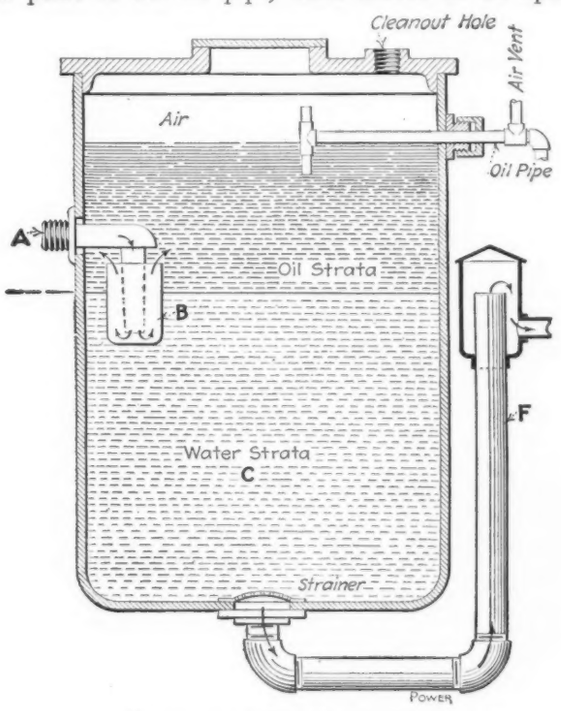
Beginning in the next issue, there will follow a series of thirteen lessons on "Problems in Power Plant Design" which will treat of the various problems entering into the design of the power and heating equipment of a large industrial plant.

Correspondence

Gravity Oil Separator

The oil and water separator described on page 279 of the Aug. 25 issue seems unnecessarily complicated.

A tank and water drain pipe, like the one described, and an oil pipe at a point higher than the level of the water drain pipe, are all that is necessary. At some high point in the oil pipe, there should be an open-



SIMPLIFIED OIL SEPARATOR

ing to allow the air to escape. I do not understand how the water can be clean after it has been in such intimate contact with oil, or where else any heavy sediment could be expelled.

LEON LEWIS.

New York City.

Machinist Engineers

I have read J. Thorn's letter on p. 930, June 30, and N. C. Gleason's, on p. 217, Aug. 11, under the above caption. I am not personally acquainted with the local conditions of the first, but Mr. Gleason is nearer my home town. Machinists do get 45 to 50c. per hr.; as to engineers, with but few exceptions, getting 30c. per hr. or less, I think it is easy to see where the trouble is.

Engineers of the class referred to are not mechanics, and cannot go very far trouble-shooting. As for Mr. Gleason's scruples against butting into another man's trade, while he is aiming to become proficient in handling electricity, is he not butting into the electrician's business? Electricians generally get higher pay than machinists.

Again, how does an engineer looking for advancement expect to qualify himself to take charge of large plants, where several fitters and machinists are employed on construction and repairs, if his knowledge is limited to what he has read in books? This kind of chief soon goes back to the 30c. per hour class.

The law in Alberta calls for 24 months of shop practice before a man can sit for a first-class license. I think it should call for 48 months' experience as a journeyman machinist in making and repairing steam engines and power-plant equipment. Having this knowledge in store, he will find it much easier and will not be compelled to call on outside help for anything which demands skill and practice. Furthermore, his employer is a poor business man if his pay does not correspond with his ability.

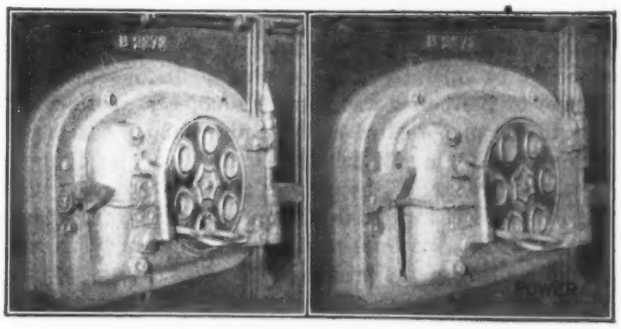
BENJAMIN J. RENDOV.

Edmonton, Alta.

Safety Catch on Furnace Door

Some time ago POWER had a cartoon showing what might happen to the attendant should a tube burst while he was in front of the door.

Having a number of large water-tube boilers under my



CATCH ON ORDINARY DOOR

charge, I decided to get up a device that would prevent such an accident. One illustration shows the door just before closing, with the catch raised ready to fall in place when the door is closed; the other has the catch down over the bar that locks it, and prevents it being forced open should a tube fail.

THOMAS J. PASCOE.

Norway, Mich.

Does Oil Attack the Engine Cylinders?

The engines in our plant are large triple-expansion machines, each having two very large low-pressure cylinders. The vacuum carried is rather high, averaging about 27 in. We have found it exceedingly difficult to lubricate the cylinders satisfactorily or so as to prevent a rapid wearing away of the cylinder walls. The engineer who erected the machines insisted on using oil in large quantities until the machine was thoroughly broken in, after which he said the quantity might be considerably

reduced. We have found, however, that instead of decreasing the supply of oil, it has been necessary to increase it, or at least that is what we have done.

Recently there has been a great deal of discussion by our engineering force, and by others outside whose opinions have been sought. Out of this discussion comes the rather startling assertion that the rapid cutting away of the cylinders, which are made of a soft, coarse, gray iron, is due primarily to the use of such excessive quantities of oil. The opinion voiced is that the acid in the oil actually eats away the iron; it is so porous that this acid readily penetrates beyond the surface.

As this is something new to me, I should much appreciate knowing whether other readers of POWER have had similar experiences, and have been able to trace them positively to the use of an acid-bearing oil.

B. F. MAYER.

Buffalo, N. Y.

Fusible Plugs

Prior to 1911, so far as I could find, a fusible plug had never been used in any of the 40 or more boilers with which I had to do, and some of them were of the latest water-tube type, and in large plants. Since then, I hope they have been so fitted. Builders of water-tube boilers do not make provision for fusible plugs except where required by law.

If composed of the proper alloy and kept free from scale, a fusible plug will melt when the water gets low enough to uncover it. I know of instances where serious trouble would have been prevented if the boilers had been protected by operative fusible plugs. In one case, the damage to the boiler was about $1000. In another, the alloy in the plug melted at low water but the coating of scale above it was so thick that it did not blow. Sometimes, the location of the plug as required by law is such that it is almost inaccessible from either side, and therefore is not kept free from scale or soot, which may prevent it from melting at the proper time.

The principal cause of low water in the boiler is the operator's neglect or carelessness. If he is watchful, he will know when anything is wrong or when the water is getting low, and will have time to either correct the trouble or get the boiler out of service before the water gets dangerously low.

Some type of fusible plug, as an independent low-water alarm, connected directly to the shell of the boiler should be required and independent of the usual high- and low-water alarm.

Feed-water regulators are a great help if properly used, but their automatic features sometimes cause the operator to become careless, and he does not watch the water level as closely as he should. Perhaps the regulator may get out of order or the feed be interrupted; then the water gets dangerously low before it is discovered.

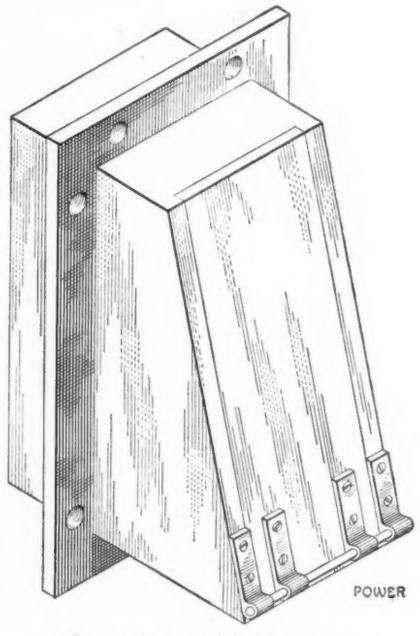
I have in mind a low-water alarm made of a piece of ¾-in. pipe extending through the top of the boiler down to the safe low-water level. The end outside of the boiler has a fusible head similar to an automatic sprinkler head, and above the fuse is a whistle. When the water in the boiler is at the proper level, this pipe is full of water and the temperature is low enough to prevent the fuse from melting. When the water lowers beyond the end of the internal pipe, the water is drained out and steam enters, melts the fuse and blows the whistle until it is shut off. A fault of this arrangement is that a valve is placed between the fuse and the boiler to permit a new fuse being inserted without letting the steam off the boiler. This valve is likely to become closed, thus making the alarm useless. Nevertheless, an independent low-water alarm is important as it gives warning before the danger point is reached.

J. C. HAWKINS.

Hyattsville, Md.

Safety Door in Setting

The editorial of May 26, 1914, concerning safety dampers interested me so much that early in June I had two doors made as shown and set into the brickwork. This



DOOR SET IN BRICKWORK

idea was suggested in a letter in POWER by one who had experienced tube trouble. Some of my brother engineers seem to think it a joke to put a safety valve in the brickwork, but I think it is a good thing.

WALLACE JOHNSON.

Utica, N. Y.

'Twas Ever Thus!

Recently I had an amusing experience which illustrates the peculiar mental attitude assumed by some men. I was consulted by the owner of a small factory, who complained about the conditions existing in his power plant. The substance of his complaint was the excessive drop in pressure between the boilers and the engine—some six pounds. He had figured out the loss in money and had about concluded to spend some in reconstructing the piping system.

Upon visiting the plant, we arrived at the engine room. Here was a simple Corliss engine of about 250 hp.; a 6-in. steam pipe led to it. There was nothing to indicate an abnormal drop in pressure—in fact, the pipe was somewhat larger than I would have used under the circumstances.

Entering the boiler room from the rear of the boilers, I saw the usual style of connection, but nothing to account for the large drop in pressure. It seemed that a one-pound drop should have covered the case as the equivalent length of pipe was less than 100 ft. I was having visions of obstructions in the piping when, on reaching the front of boilers, found the steam gage down about 7 ft. from the floor and the connecting pipe rising from the top of the boiler so as to put a head of water on the gage that measured 10 ft. 6 in. Here was 4½ lb. accounted for.

The explanation was satisfactory to the owner and he was much pleased that his trouble was really no trouble at all. The amusing (?) feature was that he did not consider my services worthy of compensation, for, as he expressed it, "Any —— fool could have told me what was the matter!"

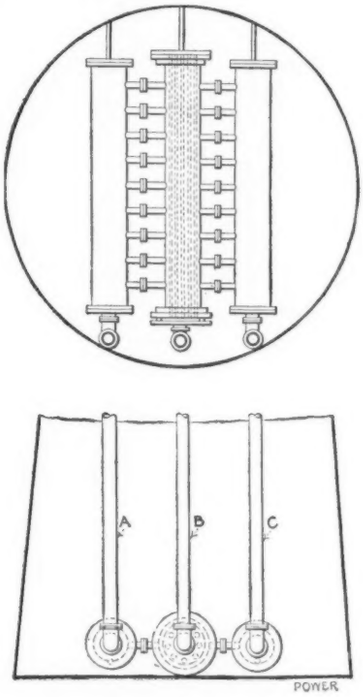
Had I recommended larger piping and work that would run up in cost he would probably have regarded me as being strictly onto my business.

C. O. Sandstrom.

Kansas City, Mo.

Water Heater in Supply Tank

An efficient submerged heater was constructed of old stock material and placed in a supply tank from a water-softening system, utilizing the exhaust from a 12x20x20 x24-in. duplex pump. The tank was 18 ft. in diameter and 14 ft. high. The construction was as follows:



Heater Submerged in Tank

One length of 20-in. and two of 15-in. pipe were drilled and tapped, as shown in the illustration, and connected with 2½-in. pipes. The larger pipe was flanged with a piece of ¾-in. boiler plate on each end, into which was expanded a number of old boiler tubes. On the front end was put a ring of 1-in. iron, which acted as a distance piece, allowing the distribution of the water through the tubes.

The steam enters through pipe *A* and flows through the smaller connections into the larger pipes; the vapor is conducted to the atmosphere through the pipe *C*. The condensate is drained through the sides of the tank and then pumped to the top. The feed water is admitted through pipe *B* into the tubes and flows out at the other end into the tank.

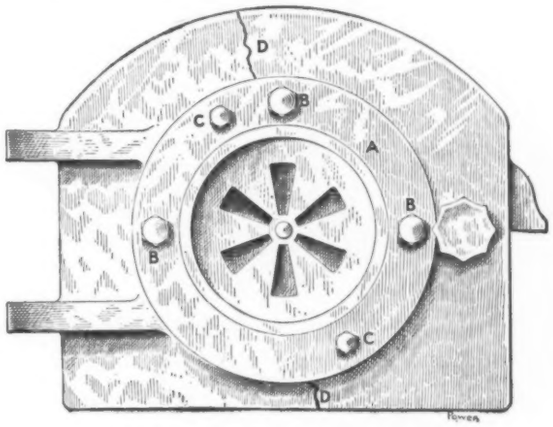
John F. Hurst.

Louisville, Ky.

Furnace-Door Repair

Up to a year ago, our furnace doors cracked and finally broke in two, as shown at *D* in the illustration.

To eliminate this trouble, we had several rings cut from boiler plate just large enough to fit over the rib around the damper, and 1¾ in. wide. These were drilled for the



Furnace Door Repaired

bolts *BBB*, which serve the double purpose of holding the ring and the door lining. The smaller bolts *CC* help to hold the two pieces together.

We have fitted all of our doors with these rings and find that they give longer service without attention than would new ones.

George B. Longstreet.

Somerville, Mass.

Crack in Boiler Shell

A recent article on patching boilers recalled an experience I had with a 66-in. by 16-ft. return-tubular boiler, in which a fire crack developed, extending from a rivet hole above the fire-doors for 4 in. on the bottom of the fire sheet. As the boiler had a flush front, the fire sheet extended 16 in. beyond where the head joins the shell.

It was at first thought that the crack was caused by cold air entering through the panels in the fire-doors used in connection with a smoke preventer, but upon removing six rivets to insert a patch over a hole left by a piece cut out of the shell where the crack occurred, it was found that the rivet holes in the head and the shell did not correspond. This made it evident that the holes had been punched to size instead of being punched small and then reamed to the proper diameter to take the rivets; also, that a drift pin had been used freely in joining the head to the shell.

The boiler is of the triple-riveted, butt-joint type, constructed of $\frac{7}{16}$-in. metal and ⅞-in. rivets; it was built for

150-lb. working pressure. To put it on the market in such a condition as representing, it is supposed, a piece of first-class workmanship and design, was hardly honest, and not only endangered the reputation of its builder, but the lives of those who operated it.

It would also seem that in the construction of steam boilers at a time when competition is keen and the cost of material is a large factor, that boiler makers, especially the small ones, are likely to neglect to remove enough metal from the edges of the rings when rolled. The edges, being cooled quicker than the interior of the shell, are in danger of hardening and becoming more brittle than that part of the shell which cools more slowly; therefore, the edges of the rings lack the toughness that should characterize a metal of high tensile strength.

Test bars should be taken from all boiler plate during construction, but where there is no law to that effect it is not always done.

La Rue H. Stark.

Delavan, Wis.

Obtaining Smokeless Combustion

To the beginner the problem of obtaining smokeless combustion is generally very complicated, but if he will bear in mind one principle, it will go a long way toward helping him to understand many of the smoke-preventing furnaces. This principle is to so construct the furnace as to cause the gases to come in contact with a hotter surface before they reach that of the boiler. Hence the reason for the large combustion arch of the chain-grate furnace, the steam jets in other types, and for forcing the gases up through the incandescent fuel in the various underfeed types.

He will also understand the great benefit derived from high settings and when hand firing will note the advantage of allowing the fuel to coke on the dead plate. The object in each case is to lead the gases to a hotter place before they come in contact with the comparatively cool boiler surface.

John F. Hurst.

Louisville, Ky.

Feed-Water Heaters

Although considerable has been written about feed-water heaters, perhaps more on the subject will not be amiss, especially on the careless way in which they are installed. Very often the heater is in some out-of-the-way place and covered with dirt, when it should be accessible and kept clean, both inside and outside, to render efficient service.

In any plant where steam escapes from the exhaust pipe and the feed-water temperature is not 200 deg. or higher, there is something wrong with the size or management of the heater.

Some engineers pay but little attention to the temperature of the feed and are indifferent to the oft-repeated statement that 11 deg. rise in the temperature of the feed water will result in a saving of one per cent. in the coal bill.

The best type of heater to use depends on the working conditions of the plant. A closed heater is not suitable where the feed water contains much scale-forming substance or where the exhaust steam is intermittent, because the tubes will become coated with scale in the one case and the sudden changes in temperature will loosen them in the other. An open heater will give better results as it is much easier to clean and is not affected by sudden temperature changes. The efficiency of an open heater is reduced by feeding too much cold water and allowing the excess to pass off through the overflow.

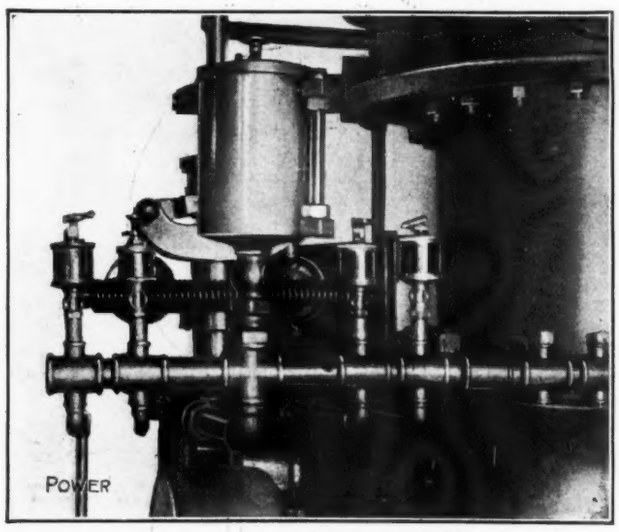
Upon taking charge of a plant at one time, I was astounded at the size of the water bill, but I discovered that the float in the heater was inoperative. The fireman told me that my predecessor wanted the heater to overflow to flush out the oil and scum. After adjusting the valve rod I made a saving of $37 in the water bill the first month and raised the temperature of the feed water 16 degrees.

Louis B. Carl.

Marshfield, Wis.

Bracket for Oil Cups

The illustration shows a simple bracket for the oil cups on a Westinghouse gas engine. I put them all in one place and piped from them to the various bearings, as those on the governor side of the engine were scattered around, some in out-of-the-way places and unsafe to reach



Bracket and Cups in Place

when the engine was running, and often neglected on that account.

The bracket is made up of 1x1x⅜-in. crosses, one 1-in. cross carrying the large cup which was tapped through and a long-thread nipple run through it with a locknut on the other side. The other cups were similarly fitted with ¼-in. pipes. This places all the cups in a line and in plain view, so that none need be overlooked when filling; they are also much easier to regulate. The bracket was fastened to the crank-case of the engine by drilling two holes and putting in two ⅝-in. studs, so that two fittings would set down over them and be clamped rigidly in place by the nuts.

L. M. Johnson.

Emsworth, Penn.

Home-Made Cable Clamp

A large number of clamps, similar in construction to the one shown by Mr. Hodges, page 171, POWER, Aug. 4, 1914, are in use on the Brooklyn Bridge at the cable crossing.

Their shape varies a trifle from the sketch shown, but the idea is the same, the cables on the bridge, however, crossing each other at the clamp.

EDWARD O. JOHNSON.

East Orange, N. J.

Queer Compressor Diagram

While indicating an ammonia compressor recently, the indicator-needle valve leading to the cylinder was throttled. A diagram taken under this condition is shown in Fig. 1. On the compression stroke the pressure in the cylinder was not able to transmit itself fully to the indicator piston; on the suction stroke the pressure in the indicator could not relieve itself quickly and follow the low pressure in the cylinder of the compressor.

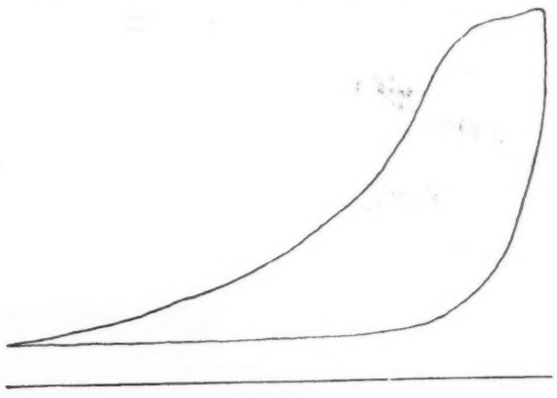


FIG. 1

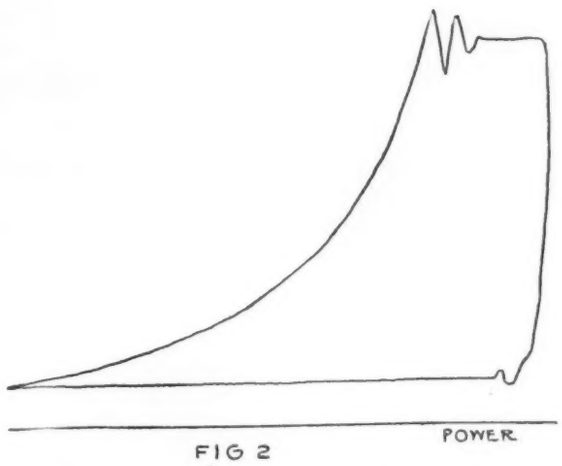


FIG 2

DIAGRAMS FROM AMMONIA COMPRESSOR

Without knowing that the valve was throttled, one might suppose that the compressor was in bad condition, the "thinness" of the diagram indicating piston- and suction-valve leakage, and the rounded "heel" showing excessive clearance.

The true diagram, taken with the valve open, is shown in Fig. 2, and it indicates that the compressor is in good condition.

There is little danger that such a freak diagram would be taken unintentionally, for the indicator valve had to be very nearly closed before any effect on the card was noticable.

G. H. CRAWFORD.

Philadelphia, Penn.

Lowering Flywheel into Pit

Installing a large Corliss engine in an out-of-the-way place with but few tools, is a trying ordeal. I know it. A few pinch bars and a jack borrowed from a section boss constituted the entire equipment. All went fairly well until it came to lowering the one-piece flywheel into the pit. It occurred to me to partly fill the pit with dry sand. Then the wheel was rolled down easily and the shaft put into it. By digging the sand out the wheel settled down until the shaft rested in the bearings.

PHILIP R. DUNTON.

McPherson, Kan.

Effect of Electrolysis on Boilers

This letter is written to bring out a healthy discussion on the above subject by those who have witnessed a similar phenomenon. A short time ago I was attracted by some boiler tubes and a head which were being loaded on a wagon. Knowing that this building had a comparatively new boiler, the need of such extensive repairs at so early a date was surprising.

It was a 42-in. by 12-ft. low-pressure boiler (10-lb. gage), containing 38 three-inch tubes and supplied heat to an office building and Turkish bath. The shell was of ¼-in. steel, with a handhole at the bottom of the front head and a 10x16-in. manhole at the top of the rear head. The boiler is insured and inspected at regular intervals, and is under the general charge of an engineer employed by the building owner, who comes over from his nearby plant every day to see to things in general.

While everything was normal, there suddenly came a roar of escaping steam from the back head, the gage at the time registering 2 lb. and the fire practically dead. At the top of the manhole, just at the bend of the flanged sheet, was a hole half an inch wide in the middle, tapering to the ends and 2 in. long, eaten entirely through the ⅜-in. sheet. Corrosion was evident all around the manhole following a general line at the bend of the sheet, but it gave way at the top first.

The cast-iron manhole plate was eaten away all around the edges of the guide ring, mostly in one spot, but *not* opposite the worst place in the head, where the blowout occurred. There was no evidence of a leak around the joint or the rivets. The boiler had been cleaned eight weeks before, and was in excellent shape, both as to scale and condition of the shell generally. The scale was only a coloring on the sheets and tubes. All this action occurred in these eight weeks and probably from the following cause:

There was a long scraper kept on top of the boiler when not in use, the handle projecting about three feet in front of the boiler, while the other end hung down about even with the rear head, resting on the brickwork. It was the habit to hang an extension cord in the projecting handle of this scraper, and it is believed that the rod became

charged, the current following down and jumping to the boiler and setting up electrolysis.

No moisture could drop down on the boiler or head, a leak is out of the question and the boiler is practically new, and has had proper care. Does this theory look reasonable? I trust that others will write of similar experiences, as I have not seen anything in POWER lately along this line.

GEORGE H. WALLACE.

Racine, Wis.

Expansion of Steam Lines

To the average engineer the expansion of steam lines is a mysterious affair, but if neglected in steam fitting he will sooner or later have lines which "somehow or other always leak."

When coupling up pipework he should never allow a strain which the expansion will increase; in other words, it is far better to have the pipe a little short when cold than to have it too long as the expansion, of course, will elongate it.

A handy rule to determine the amount of expansion is as follows: Multiply the difference in degrees temperature between the hot and cold pipe by the length of the pipe in inches and divide by the constant 150,000; the result will be the expansion in inches.

Example—Steam at 100 lb. pressure, temperature of atmosphere 80 deg. F., length of pipe 100 ft.

Temperature of steam at 100-lb. pressure = 337.8; then

$$\frac{(337.8 - 80) \times 1200}{150{,}000} = 2.062 \text{ in.}$$

or a little over $^1/_{64}$ of an inch per lineal foot.

JOHN F. HURST.

Louisville, Ky.

Knock in Low-Pressure Cylinder

Large vertical cross-compound engines sometimes knock or pound in the low-pressure cylinder. This usually occurs after the engine has been in service some time, and as the supporting base of the cylinder is generally of hollow construction, it acts as a sounding board and greatly exaggerates the noise.

The cause is that at the upper end of the stroke the piston, being supported only by the more or less flexible piston rod, is thrown against the opposite side of the cylinder by the impact of the entering steam. The operation of the admission valve being quick, the piston receives a tremendous side blow.

The effect is not evident at the beginning of the upstroke as the stuffing-box packing, etc., render the rod less flexible. The trouble is rarely experienced with the high-pressure piston as its rod is larger in proportion to the piston diameter. The best remedy is to remove the piston and increase the tension of the packing rings. With some types of pistons, removing the follower will allow access to the rings, and stiffening the packing offers more resistance to the throwing action of the steam.

Another way to stop the noise until the packing can be worked on is to increase the lead of the upper steam valve, causing a gradual action of the steam against the piston as it approaches the end of the stroke. The indicator will show excessive lead, but that is preferable to the noise.

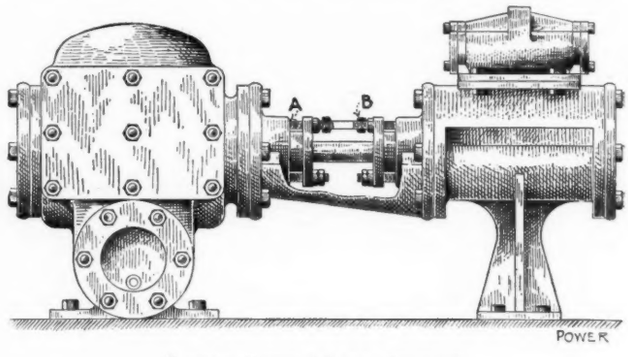
JOHN F. HURST.

Louisville, Ky.

Emergency Pump Repairs

The gland studs on pumps often show distress, especially those aboard ship, or on pumps which circulate brine. The action of the salt water tends to rust out the threads and allow the stud to pull out.

The regular repair consisted of tapping out the hole to the next larger size and fitting in a new stud having a large end threaded to fit the new tapping. Conditions do



LOOSE STUD MADE SECURE

not permit of this work being done at the time of the failure in every case, so that a temporary repair is necessary. The illustration shows how to tide over such an emergency in a thoroughly satisfactory manner.

Cut and thread a rod of the same size as the studs and just the length that will fit in between the ends *A* and *B* of the two opposite studs. With nuts screwed on flush with the ends, the new rod is then set in between the two studs and the nuts screwed half way on each stud, making a continuous rod of the three parts.

If it is desired to put an end pressure on the studs, the new rod may be unscrewed the desired amount when in place and after the first nut has been started on the stud and the other nut not entered. This will act as a jack-screw and put an end pressure on each stud.

J. A. LUCAS.

Ozone Park, L. I., N. Y.

Graphite in Boilers

The boilers in the writer's charge are cleaned semi-annually. In February of this year the use of graphite was started. On Aug. 12 one unit was cut out and the drums were found coated with a thin, spongy scale, impregnated with graphite, but the tubes were lined with a very hard scale ⅛ in. thick with no graphite in it. Why does graphite not affect the scale in the tubes?

I believe that where the circulation is not so rapid, the graphite is able to work under the scale, but that in the tubes no opportunity is given it to settle. Therefore, it is carried to the rear headers and the greater portion settles into the mud drum and is blown out.

H. A. COX.

Middletown, N. Y.

Inquiries of General Interest

Steam Pipes Should Drain Away from Boiler—Should the steam pipe leading from a boiler to an engine incline up or down from the boiler?

S. H.

All steam mains should be so sloped that the water from condensation will drain away from the boiler, thus allowing gravity and the flow of steam to work together.

Purpose of Riding Cutoff—What is the object of a riding cutoff on a throttle-governed engine?

L. W. C.

To obtain adjustment of the point of cutoff to the load of the engine operating with higher initial cylinder pressure and thus obtain greater economy by working the steam expansively through the largest possible proportion of the stroke.

Pump Becomes Steam Bound—How can a feed pump with suction from an open heater be prevented from becoming steam bound without lowering the temperature of the water in the heater?

P. S.

Operate the pump at slower speed and feed more continuously, but if that is not practicable, lower the pump or increase the size of suction pipes and connections so the suction water will be delivered to the pump cylinder with less reduction of pressure from friction.

Heat Given Up by Cast Iron in Cooling—If a bar of cast iron weighs 30 lb., how many heat units will it give up in cooling from 850 deg. F. to 60 deg. F.?

M. S. M.

The specific heat of cast iron is about 0.1298, i.e., for each degree of rise in temperature, a pound of cast iron requires the addition of 0.1298 B.t.u., and in cooling it parts with the same amount of heat for each degree of reduction of temperature; therefore, 30 lb. of cast iron in cooling from 850 to 60 deg. F. would part with

$$30 \times (850 - 60) \times 0.1298 = 3076.26 \text{ B.t.u.}$$

One Side of Duplex Pump Quicker Than the Other—What would cause one side of a duplex steam pump to move more quickly than the other side?

A. J. O.

One side may run faster than the other, because its water piston is doing less work than the water piston of the slower side and needs packing; or one side may run slower than the other because the steam supply passage has become clogged, the steam valve does not open wide enough, the steam piston leaks, or the packing of the piston or of the piston rod is too tight.

To Operate One Water Piston of Duplex Pump—If the water piston on one side of a duplex pump were to become disabled, how could the pump be run with only one water cylinder?

J. O. C.

If the disabled piston is in a condition from which it is likely to injure its cylinder, it should be removed from its rod. For continuing the operation of the other water piston, place a blind gasket in the steam supply connection of the disabled side of the pump with a small hole in the gasket for admission of only sufficient steam for overcoming friction of the disabled side and for operating the valve gear of the good side of the pump.

No Load Loss of Transformer—What energy would be consumed by a 350-kw., 440/2200-volt, 25-cycle transformer, with the primary connected to the busbars, but the secondary disconnected from the line?

C. F. S.

The losses in a transformer consist of copper (I^2R) loss, and core losses. With the line switch disconnected and the transformer carrying no load, the copper losses would be negligible, but there would still be the core losses consisting of hysteresis and eddy currents, both of which are practically independent of the load. The hysteresis varies as the 1.6 power of the voltage and directly as the frequency. The eddy current loss varies inversely as the ohmic resistance and directly as the square of the voltage. The exact value of these losses in any case would depend upon the design of the transformer. With a transformer of 350 kv.a. capacity, these losses would probably amount to about 1 kw. per hour.

Load Raised by Plunger Elevator—What weight can be lifted by a direct plunger elevator operated with 160-lb. pressure per square inch, the diameter of plunger being 8 in., and the weight of the plunger and car being 1700 lb.?

T. J. M.

The total lifting force exerted by the pressure of the water on the plunger would be the square inches of cross-sectional area of the plunger multiplied by the water pressure per square inch or

$$(8 \times 8 \times 0.7854) \times 160 = 8042.4 \text{ lb.},$$

allowing 5 per cent. loss due to friction of the plunger packing and guides, then the lifting power of the plunger would be

$$8042.4 \times 0.95 = 7640.28 \text{ lb.}$$

If the plunger and car weighing 1700 lb. are uncounterbalanced, then the net weight that could be lifted would be

$$7640.28 - 1700 = 5940.28 \text{ lb.},$$

and if counterbalanced this would be increased by the amount of counterbalancing weight employed.

Meaning of Cycle in Engineering—What is the meaning of a cycle as used in engineering?

L. E. J.

In its broadest sense, a cycle is a period marked by the beginning and completion of a reoccurring round of events. Applied to thermodynamics, it is a series of operations in which heat is given to or taken away from a working substance (such as steam, gas, etc.) which, by expansion, gives up part of its internal energy in the form of mechanical work, and by compression or by the addition of heat has its internal energy restored and is brought back to its original state. Electrically, it means a complete positive and negative wave of electric current. In alternating current, a cycle embraces the complete period from zero voltage to maximum in one direction, returning through zero to a maximum in the other direction and back again to zero. In gas-engine terms, a cycle is one complete series of events. For instance, a "four-stroke cycle" means that it takes four strokes to complete the operation. The mixture starting with the intake on the first stroke, is compressed on the second (return) stroke; its ignition and expansion take place on the third stroke, and the gases are expelled on the fourth or exhaust stroke, whereas in the "two-stroke cycle" engine these events are accomplished in two strokes.

Horsepower of a Waterwheel—What is the formula for computing the number of horsepower of a waterwheel?

W. H.

If

Q = Number of cubic feet of water discharged per minute;

D = Weight of a cubic foot of water = 62.36 lb. (at 60 deg. F.),

and

H = Total head in feet,

then the gross power or horsepower of the water is

$$\frac{Q \times H \times 62.36}{33{,}000} = 0.00189\ QH$$

But a waterwheel or motor cannot utilize the whole of the head as there are losses of head at the entrance and exit and also losses of energy due to friction of moving parts of the wheel. The fractional part of the power of the water which the waterwheel is capable of delivering as useful power is called the percentage of efficiency of the wheel. Calling E the percentage of efficiency then for Q cubic feet of water per minute and H total head in feet,

$$\text{Hp. of the wheel} = 0.00189\ QH \times E.$$

The value of E varies with Q, H and the r.p.m., and with most types of turbines it also varies with the amount of gate opening. A fair average for a good turbine wheel may be taken at 75 per cent. efficiency, but the efficiency assumed for any case must be that which has been determined for a given set of conditions.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Elementary Mechanics--XXX

Last Lesson's Answers

136. In Fig. 85 let the distance between the centers of the pulleys M and N be 10 ft. or 120 in. Draw the line of the belt. Its arc of contact on the small pulley will be the angle BAE which is equal to 180 deg. minus twice the angle DAB. From the center of the small pulley N draw the line AR parallel to the line CB. Then since the line AR is at right angles to the line AB and the line AO makes 90 deg. with the line AD it is evident that angle DAB = angle a = angle RAO. The line OR is equal to the radius of the large pulley minus the radius of the small pulley or line $OR = (15 - 9) = 6$ in. The sine of the angle RAO is equal to $\frac{OR}{OA} = \frac{6}{120} = 0.05$ and from a table of sines the value of a is found to be (2 deg. 50 min.). Therefore, the arc of contact is

$$(180 - 2 \times 2 \text{ deg. } 50 \text{ min.}) = 174 \text{ deg. } 20 \text{ min.}$$

137. From equation (83) $log_{10}\left(\frac{T_1}{T_2}\right) = 2.73 \times f \times N$, where f = the coefficient of friction = 0.3, and N = the ratio of the arc of contact in degrees to 360 deg. or $N = \frac{174 \text{ deg. } 20 \text{ min.}}{360} = 0.484$. Hence

$$log_{10}\left(\frac{T_1}{T_2}\right) = 2.73 \times 0.3 \times 0.484 = 0.396$$

and from a table of logarithms the value of $\frac{T_1}{T_2}$ is found to be 2.49 or $T_1 = 2.49\ T_2$.

138. Since the belt is 12 in. wide and good for 60 lb. per in. of width the maximum tension T_1 that may be put on the belt = (12×60) or 720 lb. The effective driving effort $P = (T_1 - T_2)$ and from the above problem $T_1 = 2.49\ T_2$, or $T_2 = 0.4\ T_1$; hence
$P = (T_1 - 0.4\ T_1) = 0.6\ T_1 = (0.6 \times 720) = 432$ *lb.*
The linear velocity of the belt = r.p.m. $\times$ the circumference of the smaller pulley or

$$V = 300 \times 3.1416 \times 1.5 = 1413 \text{ } ft. \text{ } per \text{ } min.$$

and from equation (55)

$$hp. = \frac{P \times V}{33{,}000} = \frac{432 \times 1413}{33{,}000} = 18.5$$

139. The rule states that a belt traveling at 900 ft. per min. will transmit one horsepower per inch width of belt. If traveling at 2700 ft. the belt will evidently transmit $\frac{2700}{900}$ or 3 hp. per inch of width and as the total width of the belt is 15 in. the total horsepower transmitted will equal 15×3 or 45 hp.

140. The horsepower transmitted by a double belt = 1.4 times that of a single belt, hence in this case a double belt would transmit 1.4×45 or 63 hp.

Review

Mechanics is that branch of science which has to do with forces and their action on bodies tending to produce a state of motion, change of motion, or condition of rest of these bodies. This study of forces is divided into two general classes of statics and kinetics, the former dealing only with forces which keep a body in a state of rest and the latter dealing with forces which produce motion. The first nine lessons of this course covered the general idea of statics and Lesson X gave a résumé of the conditions which produce a state of equilibrium of all the forces acting so as to insure a state of rest of the bodies.

In Lessons XII, XIII and XIV, these laws of equilibrium were applied to the various forms of machines such as levers and pulleys including the Weston differential pulley. This idea of a machine naturally led to Lesson XIV where a few general notions of friction were given. It was shown that the force of friction acting between two bodies was directly proportional to the coefficient of friction times the normal pressure between the objects. To find the normal pressure it is necessary to resolve all the forces acting on the body into their components at right angles to the bodies. The algebraic sum of all these components will give the total pressure tending to produce friction. The algebraic sum of the components parallel to the bodies will produce or tend to produce motion of the bodies one on the other.

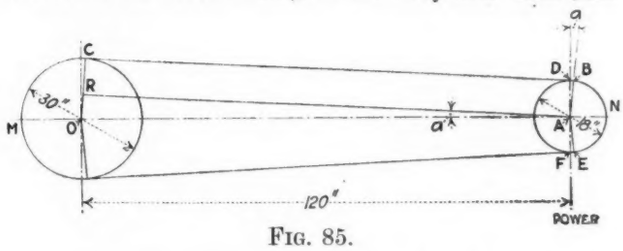


Fig. 85.

With the force of friction overcome, the next logical step is to study the laws which produce motion of bodies and to determine under what conditions a system of forces will be in equilibrium even *though the objects are in motion at a uniform rate of speed.* In Lesson XV the general conception of motion was dwelt upon and as in statics so in kinetics it was found that velocities might be represented by straight lines; that they might be reduced into components in any desired direction, and moreover that a system of velocities could be replaced by a single velocity which would produce exactly the same motion as the combined action of all the other velocities.

The relations between the acceleration, velocity, time and space traversed by bodies were worked out in considerable detail and for handy reference these formulas* may be summarized as follows, first, however, dividing moving bodies into six general classes, thus:

Class I—Bodies having uniform motion.

Class II—Bodies starting from rest and moving with uniformly accelerated motion.

Class III—Bodies moving with an initial velocity and then acted upon by an accelerating or retarding force.

*The numbers opposite the equations are the same as used in the various lessons.

Class IV—Bodies falling freely under the action of gravity.

Class V—Projectiles, subdivided into,

(a) Bodies projected horizontally from a point at some elevation above a given reference plane.

(b) Bodies projected at an angle to the horizontal.

Class VI—Rotating bodies.

All problems coming under Class I may be solved by the relation that,

$$S = V \times T \qquad (27)$$

where

V = The uniform linear velocity in feet per second;
S = The space traversed in feet and;
T = The total time of motion in seconds.

Problems coming under Class II are solved by the following laws:

$$V = a \times T \qquad (30)$$
$$S = \tfrac{1}{2} a \times T^2 \qquad (31)$$
$$V^2 = 2a \times S \qquad (32)$$

where

V = The final velocity in feet per second;
S = The space traversed in feet;
T = The total time in seconds, and;
a = The acceleration in feet per second per second.

The formulas for problems coming under Class III are:

$$S = U \times T \pm \tfrac{1}{2} a \times T^2 \qquad (34) \text{ and } (38)$$
$$V_1 = U \pm a \times T \qquad (35) \text{ and } (39)$$
$$V^2_1 = U^2 \pm 2a \times S \qquad (37) \text{ and } (40)$$

where

U = The initial velocity in feet per second;
V_1 = The final velocity in feet per second;
S = The space traversed in feet and;
a = The acceleration or deceleration in feet per second per second.

The relation between the various items for falling bodies under Class IV are:

$$V = g \times T_1 \qquad (41)$$
$$H = \tfrac{1}{2} g \times T^2_1 \qquad (42)$$
$$V^2 = 2g \times H \qquad (43)$$

where

H = The height of fall in feet;
V = The velocity at the end of a fall of T_1 seconds duration, and;
g = 32.16 = the acceleration in feet per second per second due to gravity.

The laws for projectiles under Class V, Case *a*, are expressed by the relations:

$$T_1 = \sqrt{\frac{2H}{g}} \qquad (67)$$
$$R = V \times T_1 \qquad (68)$$
$$R = V\sqrt{\frac{2H}{g}} \qquad (69)$$

and for Class V, Case *b*:

$$T_1 = \frac{2V \times \sin a}{g} \qquad (70)$$
$$R = V \cos a \times T_1 \qquad (71)$$
$$R = \frac{V^2 \sin 2a}{g} \qquad (72)$$
$$H = \frac{V^2 \sin^2 a}{2g} \qquad (73)$$

where

T_1 = The total time of flight in seconds;
H = The maximum altitude reached by the projectile or is equal to the elevation of the point of projection in feet;
R = The range in feet;
V = The initial velocity of projection in feet per second;
a = The angle of projection in degrees and;
g = 32.16 = the acceleration in feet per second per second due to gravity.

The most common law for rotating bodies as described under Class VI may be stated as an equation which gives the centrifugal force of a weight of W pounds, rotating at N revolutions per minute at a distance of R feet from a fixed point of rotation, thus,

$$C = 0.000341\, W \times R \times N^2 \qquad (80)$$

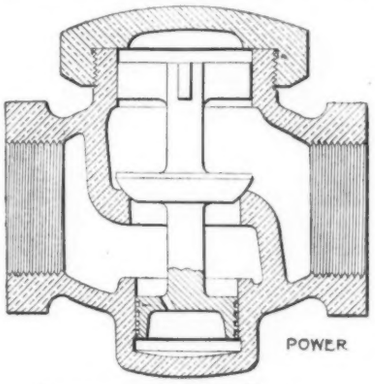
With the idea of motion clearly fixed in mind, it is an easy step to the conception of the term work which has been defined as the overcoming of a resistance through a given distance. The formulas for the work done by various types of machines such as engines, pumps, motors, etc., are almost innumerable. If the student will very carefully analyze his problem he will find that in all probability all his examples relating to work may be solved by the general equation that,

$$\textit{horsepower} = \frac{\textit{force in pounds} \times \textit{distance in feet}}{\textit{time in minutes} \times \textit{efficiency} \times 33{,}000}$$

Indicated horsepower, brake horsepower, output and input of pumps, generators, etc., may all be found by applying the above equation with the use of the proper *coefficient of common sense, which is, after all, the most essential factor in the solution of any and all problems no matter how simple or how difficult.*

Powell White Star Dashpot Check Valve

This check valve is designed to be placed on either a suction or discharge line, and on the pipe line between the discharge end of an air compressor and the receiver tank. It is guaranteed to be noiseless and airtight and easily reground. The dashpot disk has wings on the upper end which act as a guide so that the disk will seat centrally in the valve body. The lower end of the disk in the dashpot of the body forms a cushion, thereby preventing the disk from pounding heavily on the valve seat.



SECTION THROUGH DASHPOT CHECK-VALVE

There are only three parts and they are interchangeable. The valve is made in sizes from ⅛ to 3 in. by the William Powell Co., Cincinnati, Ohio.

ERRATA—On page 473, Sept. 29 issue, the statement that the average weight of heaped **coal** is 30 lb. per cubic foot is an error as it should read **coke** instead. On page 468 of the same date the weight of a cubic foot of heaped coal is correctly stated as 51¾ lb.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Oh, Rustem Bey, you've gone away;
Let's hope your guff will cease.
While Turkey's never known us, Bey,
We've been all over grease.
—Engine-Room Ballad.

Here in New York they say we're suffering from departmental inertia. Reckon they're right if "inertia is the inability of a body to change its condition of rest or motion unless some force acts upon it." Nobody home?

Man died recently who was known as "Happy Days" Pittman. The title sounds good. Lines are so tightening around us these days that the "smile" wrinkles are giving way to frowns, the grouch is infecting us, and the kicker makes more noise than the funny sheet. "Happy Days" and "Smiling Johns" are too infrequent. Be one, and get popular. As the coon said about the battle, "You-all has a right smart day for it!"

Another rotary engine has been discovered by a daily paper out in Pun-Punk— Let it go at that! Of course, it's going to mark an ee-poch in the history of steam power. "This 8-hp. engine might be placed in an ordinary cheese-box," says this paper. Perhaps it will be.

If the operating engineering business gets dull, you might start something—say a skunk farm. Man in Greenfield, Calif., did this on a small scale, and now he is on the way to wealth. He says they just love human companionship and become great pets. But don't get 'em real angry; they stop loving you then!

Our much esteemed contemporary "Buildings and Business Management" is a paper after our own heart. The October front cover has John Bunny and his yard-wide smile just reaching right out to the reader. Underneath, is the caption "Smile! Business Is Good. Help Make It Better!" Here's Optimism for you, and more—it's sound common sense! Root for good times and we'll have them, feller. Buck up!

The Franklin Institute Year Book for 1914 has reached us. But the big place the Institute occupies needs no meed of praise from us. Of this truly great institution may be repeated, without irreverence, Washington's encomium of Benjamin Franklin—it is "venerated for benevolence, admired for talents, esteemed for patriotism, beloved for philanthropy."

"The Right Time to Eat" earns an editorial for itself in the "Scientific American," and it extends from glycogenic functions right up to 8 o'clock p.m. We hold with Woods Hutchinson that the right time is when we're hungry, and then eat just one square meal; no more.

"Bursting Boiler Spreads Panic Among Widows," says a daily paper. Hey, editor, why start picking on the widows? If your wife were a widow you wouldn't be busting boilers in this loose fashion. You'd be shov—. Well, you're the best judge of what you'd be doing.

Through the generosity of Frank Thomson, there is a fund whereby sons of living and deceased employees of the Pennsylvania R.R. are being educated in technical schools. Power-plant owners and managers, please take notice.

What Sherman said war was still goes. But our cartoon foreword in this issue brings it into more intimate relation by labeling it "The paralysis of industry." Perhaps no man more nearly works by the sweat of his brow than the fellow in the boiler room. And to take away his means of livelihood creates a veritable Gehenna for him and his. Let us be thankful for peace and our jobs.

We have about a million boilers in this country of less than a hundred million people. Looks like we need those standard specifications right quick. Don't want to talk politics, but the governor, the mayor and the legislature feller who refuses to do his little bit to help lessen the explosion hazard from now on, won't get our vote.

Protecting Three-Phase Motors

By Albert M. Robinson

When three-phase motors are automatically controlled, a fuse sometimes blows, and when the control switch is closed, the motor will not start single phase, but will draw an excessive current, which if allowed to continue will burn the windings. If the motor is operating when the fuse burns out, it will continue to operate single phase and do no harm, but as soon as it stops, the current should be shut off.

Referring to the diagram, *B* and *C* represent the self-starter switches and *A* a relay. These are operated by solenoids; that is, solenoids when energized bring the two surfaces of the switches together by a clapper action; they are then held magnetically or mechanically by dashpots. The relay is constructed along the same lines except on a smaller scale, as it is designed to carry a small current for a short time only.

It is customary to have one line connected solid to the motor as 3. Lines 1 and 2 are left open to be closed

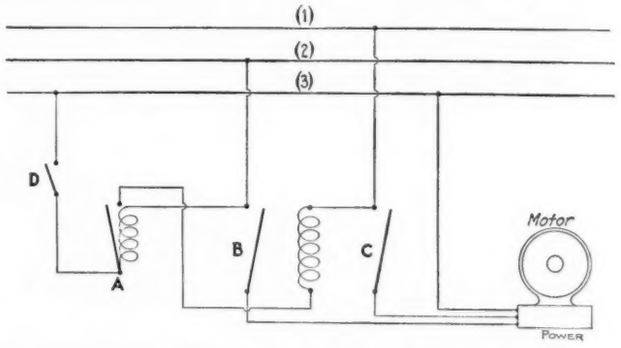


Diagram of Relay and Self-Starting Switch Circuits

by the self-starter switches *B* and *C*. Lines 3 and 2 are connected momentarily through the solenoid of the relay *A*, and when this relay is closed, then 3 and 1 are connected momentarily through the solenoid of switches *B* and *C*.

The sequence of operation is as follows: When the control switch *D*, which may be a snap switch for remote control, float switch or pressure regulator, is closed, current passes through the solenoid of the relay *A*, and when the solenoid is sufficiently energized the relay is closed, causing sufficient current to flow through the solenoid of the self-starter switches *B* and *C* to close them. When *B* and *C* are thus closed, all three lines are connected to the motor and it will operate.

If line 1 is severed by a burnt fuse or otherwise, when the control switch *D* is closed the relay will be closed, but as no current can be passed from 3 to 1 on account of 1 being severed, the self-starter switches cannot be closed nor the motor operated. Should line 2 be severed, the relay *A* will not be closed, hence there will be no operation. Likewise, should line 3 be severed, no current will reach the relay, and the motor will not start.

Another method sometimes used consists of using overload relays, but on account of its greater cost, the abovementioned method recommends itself.

A Surplus of $80,000, after deducting all expenses, including a large depreciation reserve, is the record shown by the annual report for the municipal electric-light plant of Winnipeg, Can. A significant fact is that less than 15 per cent. of the gross revenue is derived from municipal works.

Gas-Engine Valve Setting

By G. W. Muench

SYNOPSIS—Discussion of the causes leading to altered valve timing and simple directions for the proper resetting of the valve-gear.

Trouble is often caused in reassembling the valve-gear after the engine has been taken down for repairs. The novice who tries to overhaul an engine invariably has his troubles when it comes to the resetting of the valves. Many mechanics in the repair shops get the valves set "somewhere near correct" and let it go at that, the result being loss of power, misfiring, overheating, inefficient operation, etc.

The valve-operating mechanism, ordinarily called valve-gear, depends upon the shape of the cylinder and valve arrangement, and, therefore, varies in detail with different engines. However, regardless of the valve-gear arrangement and the number of cylinders, the camshaft of a four-stroke-cycle engine must always operate at one-half the crankshaft speed since it requires two revolutions of the crankshaft to perform a cycle. For this reason the cam-gear ratio is one to two, the larger gear being on the camshaft.

Valve-gear troubles causing a change in the valve timing and valve lift are due mostly to wear of the various parts, unless improperly assembled; a few of the common defects are as follows:

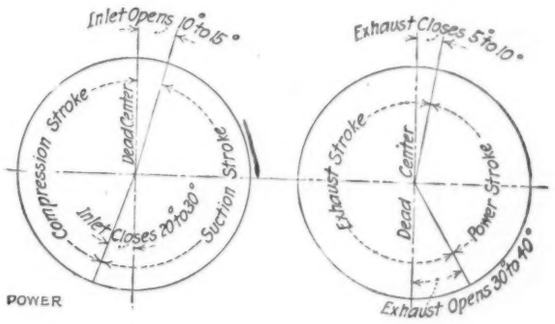
Worn cams, push rods, and rollers will reduce the lift of the valves besides changing the timing. If the cam is worn badly it should be replaced unless part of the shaft itself, when, of course, the entire shaft must be replaced. Worn push rods not only change the valve timing, but cause the engine to run noisily. In order to prevent this noise the distance between the push rods and the valve stems should be about $\frac{1}{32}$ in. and somewhat more for large engines. This clearance should not be too small, as otherwise the valves will not be allowed to seat when the engine becomes hot, due to expansion of the parts. For this reason it is well to adjust this clearance when the engine is hot.

Worn cam gears also cause enough lost motion to slightly change the valve timing; this, however, will hardly be as objectionable as the noise caused by these worn gears. An inexperienced operator often imagines his engine ready to go to pieces because of the noise caused by the lost motion in the cam gears. Gears improperly meshed are due to an error in assembling and more often ignorance of the man doing the work. Even one who does not know how to set the valves should not get into this trouble, as it is necessary only to mark the teeth on the gear so as to avoid mistakes in reassembling. Worn camshaft bearings change both the timing and the lift of the valves. If the bearings are really badly worn the lift will be so much reduced as to considerably affect the free passage of the gases.

Loose cams will cause a change in the valve timing and produce grinding and thumping. If the cams are keyed the keyways or keys themselves may be worn; or if pinned the holes may be worn, in which case they should be reamed out before putting in the new pins. Often pinned cams will shear the pins and slip a little and then become jammed.

Some engines have two camshafts, one for the inlet valves and one for the exhaust valves. Trouble with either will, of course, affect the running of the engine; it will change the setting of either the inlet valves or the exhaust valves, not both. If worn cams have lessened decidedly the total duration of valve opening a segment can often be dovetailed into the cam so as to hold the valve open longer. If this is done it should be on the closing face as wear is less on that surface.

The exact time at which the valves of a four-stroke-cycle gas engine should open and close depends upon a number of conditions; however, the speed is the principal factor that determines the setting. Just where to draw the line between high- and low-speed engines is not



Valve Diagrams

easy, but ordinarily, so far as velve setting is concerned, an engine is high speed when running at 600 or 700 r.p.m. and over.

Valve timing is expressed in degrees of crank angle, that is the angle formed by the crank with the center line of the cylinder at the time the valve starts to open or is closed completely. Automatic valves, of course, can have no predetermined time of opening or closing as they are not mechanically controlled. Engines with offset cylinders are timed the same as those having the center line of the cylinder in direct line with the crankshaft, the only difference being in locating the exact dead center. The valve setting for slow-speed engines should be as follows:

The intake valve should open about 10 degrees past dead center at the beginning of the suction stroke, and should close at from 10 to 15 degrees past dead center at the beginning of the compression stroke. The exhaust valve should open about 30 degrees before dead center at the end of the power stroke and close about 5 degrees past inner dead center at the beginning of the suction stroke.

The valve timing for high-speed engines should be as follows: The higher the speed of the engine the less the time required to fill the cylinder with fresh gas and to exhaust the burnt gases; therefore, the greater the angle of advance necessary with the valves. The inlet valve should open about 15 degrees past dead center at the beginning of the auction stroke, and close about 30 to 35 degrees past outer dead center at the beginning of the compression stroke. This setting allows considerably

more time for the engine to get a cylinder full of gas at the higher speed, allowing the valve to remain open through a greater angle. The exhaust valve should open about 40 degrees before outer dead center at the end of the power stroke and close about 10 degrees past dead center after completing the exhaust stroke.

This setting also gives the engine at this higher speed a better opportunity to get rid of the exhaust gases. Even though the valve setting is not as accurate as it should be, the exhaust valve should never close before dead center at the end of the exhaust stroke. Nor should the intake valve ever open before the exhaust valve has closed. The intake should open about 5 degrees after the exhaust has closed.

To the average operator it seems strange that the exhaust valve is made to open before the power stroke has been completed, and that the intake valve is allowed to remain open even after the compression stroke has started. Although it may seem that the engine is robbed of part of its power stroke as well as of part of its compression stroke, as a matter of fact, the operation of the engine, both from a standpoint of power and economy is bettered. During the suction stroke the gases enter the cylinder at a velocity of 4000 to 5000 ft. per minute. Traveling at this velocity the gases have enough momentum to keep them going into the cylinder for a short time even after the piston has already started on the compression stroke This insures getting a cylinder full of fresh gas.

If the mixture is correct the combustion of the gases should have been completed long before the end of the power stroke is reached, and during the last 30 to 40 degrees crank travel on the power stroke comparatively little expansive power is left in the expanding gases. For this reason the exhaust valve is opened before the stroke is completed as the extra time thus allowed for exhausting the burnt gases is of more importance than the little power that might be left in the gases.

A simple problem will serve to illustrate the method of finding the valve setting of an engine. Assume the engine to have a 70-in. flywheel, then the circumference equals 70x3.1416, or 219.9 in. To determine the time at which the intake valve opens place the engine on inner dead center at the beginning of the suction stroke. Having marked the dead center on the flywheel, turn the engine in the proper direction until the valve just starts to open, mark this position on the flywheel and measure the distance to dead-center mark on the flywheel. We will assume this distance to be 5.75 in. This in terms of the crank angle equals $5.75 \div 219.9 \times 360$, or very nearly 9.4 degrees. Or by dividing 360 by 219.9 gives the degrees per inch or approximately 1.63 degrees. Now all that is necessary to get the crank angle for the valve setting is to multiply the distance on the flywheel between dead center and time of opening or closing of the valve by 1.63, which would be $5.75 \times 1.63 = 9.37$ degrees.

Notes on Commutation*

Blackening of the commutator, high mica, and rapid wear of the copper and brushes may be credited to actual burning or something similar to electrolytic action, occurring under the brushes. It is usually not the bright sparks at the brush tips which cause trouble, but the unnoted sparking under the brush face. There is a tendency for minute particles of the conducting material to be burned or carried away from the contact surfaces, depending on the direction of the current. These particles appear to travel in the direction the current is flowing, but do not always deposit on the opposite contact surface. If the current is from the brush to the commutator, the brush surface tends to be eaten away. With ordinary current densities and low loss in the brush contact, this action seems minute, but appears to increase rapidly with increased loss at the brush contact. Therefore, high current density in the brush contact may produce this action. This does not mean high density due to the working current alone, but the high actual density, due to both working and local currents. In noncommutating-pole machines and in commutating-pole machines with bad adjustment, the local current under the brush may exceed the working current. As this adds to the working current at one edge of the brush and subtracts from it at the other edge the result will be a greatly increased density under one part of the brush, which may mean burning away one edge of the brush surface. This usually is most noticeable where the current passes from the brush to the commutator, but at the holders of the other polarity, a similar action is tending to burn away the commutator copper.

HIGH MICA

However, the commutator mica does not tend to burn away, and if the mica does not wear down mechanically at the same rate that the copper burns away, eventually the mica stands an infinitesimal amount above the copper. Therefore, the brushes will make poorer contact with the copper. This increases the loss at the brush contact and increases the burning action, resulting in still poorer contact, so that the trouble becomes cumulative. If, however, these periods of burning are intermittent, due to variable load conditions, and there is considerable operation at lighter loads or non-burning conditions, the mica may wear down somewhat and the commutator and brushes may polish sufficiently during these periods to mask the direct effects of the burning. But the results may show in grooving and apparent rapid wear of the commutator face. There may thus be burning without blackening, or without direct evidence of high mica.

Where one edge burns over a distinct area, it usually may be assumed that the burnt area could just as well be cut away, with but little harm to the operation, and possibly some good, for the fewer the commutator bars that the brush spans, the lower will be the total short-circuit current, as a rule. Moreover, by doing away with the localized burning under the brush, it may be assumed that the commutator burns less also. Cutting away part of the brush face, however, will crowd the working current into the remaining portion where burning may be increased. Therefore, narrowing the brush face is not a general remedy for the trouble, although successful in some cases.

DEPOSITS OF COPPER ON BRUSH

Burning of the commutator may also be coincident with a deposit of copper on the brush face. This gives the equivalent of low resistance brushes, with consequent increase in local current and still greater burning action. Moreover, with several brushes in parallel, any brush with copper on its face, may tend to take more than its share of the total working current, which tends to cause further heating and burning. Increased heating in itself will cause a greater tendency of the brush to take an undue proportion of the current, for carbon brushes have a negative coefficient of resistance. Such action, if continued, will eventually so destroy or injure the brush contact that it carries a decreased current, the resistance increases, and eventually the current falls, not only to normal, but probably far below normal value, due to bad contact, and the other brushes must then assume an excess. If other brushes repeat this action then the conditions become increasingly bad for the remaining brushes, and they may repeat the same action. In time, all the brushes may thus become badly burned or honey-combed.

Such conditions are often difficult to correct. In some instances, higher resistance brushes bring improvement, while in others, lower resistance brushes are better. If the local currents are relatively small and the burning or picking up of copper is due principally to the working current, then a lower resistance brush may actually reduce the watts at the contact, even though the local current may be increased.

*Excerpts from a paper by B. G. Lamme before the Association of Iron & Steel Electrical Engineers.

If, on the other hand, the local currents are high and are principally responsible for the burning action, a still higher resistance brush may reduce the loss.

UNDER-CUTTING MICA

Another remedy for some of the foregoing troubles is under-cutting the mica between commutator bars. This does not remove the primary cause of the trouble, namely, the large local currents or high current density on the brush contact, but it lessens the harmful effect of these by allowing the brush to maintain better contact with the commutator. In this way the burning action can be diminished, in most cases to such an extent that the commutator face will polish, and this in turn will enable the brush to make better contact with the copper. Undercutting in general is advantageous where the mica takes up a relatively large portion of the total surface, such as 20 per cent. or more. The general practice at present with non-undercut commutators is about $\frac{1}{32}$ in. thickness between bars; considerably less than this, as low as 0.018 to 0.020 in. is not unusual in small machines which are not undercut. Where the commutators are undercut, there is a liability of carbon dust collecting in the slots and short-circuiting between bars, unless the peripheral speed is sufficient to keep the slots clear. Therefore, in slow-speed commutators which are undercut, it may be necessary at times to brush out the slots. In high-speed commutators, or in variable-speed machines which intermittently reach high speeds, there is usually but little difficulty from carbon collecting in the slots.

Slotted commutators, while advantageous in some ways, present certain operating objections in others. Except where the brushes cover several bars, the slotted commutators are likely to produce chattering of the brushes, unless frequently lubricated. Therefore, with such commutators, self-lubricating brushes are recommended. These brushes usually contain, or consist of graphite, and generally are of lower resistance than ordinary carbon brushes; therefore, they are not as useful in assisting commutation. In commutating-pole machines where the resistance of the brushes is of relatively less importance, graphite brushes are often satisfactory. As such brushes are usually soft, they are not well adapted for wearing away the mica in commutators which are not undercut.

COMMUTATING-POLE MACHINES

In the application of the commutating pole to direct-current machines, certain conditions have arisen which are peculiar to this construction. For instance, according to theory, the flux of the commutating pole should rise and fall directly in proportion to the armature current. This means that there must be practically no saturation in the commutating-pole circuit. Probably many of the early difficulties of commutating-pole machines were due to a lack of appreciation of this point. Also, in machines with rapidly changing current, the commutating-pole flux should change at the same rate as the armature current, otherwise the proper local current conditions for commutation are not obtained. This means that the commutating field winding should not be adjusted or varied in strength by means of a noninductive shunt, as is common practice in adjusting series field windings. As the commutating-pole winding is normally inductive, then in the case of a sudden change in current, an improper proportion of the current will flow through a non-inductive shunt at the time that the armature current is changing. Either no shunt should be used, or, if one is necessary, it should have the same inductance as the commutating field circuit. The former is preferable but requires most accurate designing.

Another requirement in commuting-pole machines is accurate setting of the brushes. As a certain definite value of the local or commutating current is desired in the short-circuited coil, it is obvious that the coil must be short-circuited by the brushes at some definite position with respect to the commutating pole. This is especially true in reversing machines. Otherwise, the commutation in the two directions would not be alike. Furthermore, an incorrect setting of the brushes, with respect to the commutating pole, will have a slight effect on the inherent regulation of the machine. In a direct-current generator, for instance, with the brushes set so that commutation is exactly central to the commutating pole, the magnetic flux of these poles has no resultant effect on the generated electromotive force of the armature winding as a whole, and therefore has no effect on the regulation. But if the brushes are shifted ahead of this correct point in a generator, part of the commutating pole flux becomes effective in generating an electromotive force in opposition to the armature electromotive force. A backward lead in the same way would tend to increase the armature electromotive force. Thus the inherent regulation of the generator is affected by the brush setting. In a motor with commutating poles, a forward lead of the brushes tends to increase the counter electromotive force generated and thus tends to lower the speed with increase in load, while a backward lead tends to increase the speed. With perfect setting of the brushes with respect to the commutating poles, and an adjustment of the commutating pole strength just sufficient to give the theoretically ideal short-circuit or commutating current, the commutating poles should have practically no effect on the speed.

In actual practice, in direct-current motors, it is found better to over-compensate slightly—that is, to make the commutating pole slightly stronger than the ideal value. This increases the local or commutating current above the ideal value so that commutation is well completed before the coil leaves the brush. This gives less sparking at the brush edge, and apparently is more satisfactory from the operator's standpoint. But this overcompensation has an effect on the speed characteristics of a motor. The zero point of the current is shifted backwards; therefore, it tends to speed up the machine, this speeding-up tendency varying with the load.

Obviously, as this effect is a function of the armature current, it should be corrected by means of the armature current. This is readily accomplished by adding to the main field winding a small winding in series with the armature, and connected to magnetize in the same direction as the shunt winding on the field poles. The ampere-turns in this compensating winding are normally small, being just sufficient to balance the effect of the excess short-circuit current in the commutated armature coils. In adjustable-speed machines, at low speed and full field strength, this small compensating winding has little effect, as it is so small in proportion to the shunt ampere-turns. At the highest speeds, however, where the shunt ampere-turns are low and the rise in the speed curve is likely to be greatest, this compensating winding has the greatest effect. Hence, it tends to produce proper compensation at all speeds and loads.

PITTING

Another phenomenon in direct-current machines, which often has been falsely credited to commutating conditions, is that of "pitting," or "eating away" of the mica between commutator bars. This has also been credited to high voltage between bars, too thin mica, quality of carbon brush, use of lubricants, etc.

Some years ago, the writer and his associates made an extended study of this matter, based upon a large number of cases of actual trouble. The results from machines in actual service were so conflicting that no positive conclusions could be drawn. However, eventually the evidence pointed to oil as one of the fundamental conditions in this trouble. Extended tests were then made to determine the effects of oil on the mica, and the results indicated clearly that those insulations which absorb oil were liable to pit or eat away in time. Apparently where the oil could dissolve out the binding material in the mica, minute particles of carbon or copper would be disseminated through the mica, thus decreasing its resistance locally. Combustion of these particles would usually be noticed as "ring-fire" around the commutator. Ring-fire is almost always due to incandescent carbon particles scraped off the brushes, but is not usually harmful if the mica adjacent to the spark does not burn or deteriorate. Experience shows that the ordinary good grades of mica plate are not affected by such ring-fire, and it is only when foreign conducting particles penetrate into the plate that this burning may gradually eat away the mica. It was found that some binding materials used in building mica plate were more soluble in oil than others, and it was noted that in those plates with soluble binders, the pitting was most pronounced. This led then to one solution of the pitting trouble, namely, the use of what might be designated as insoluble binders in the mica plate, with very tight construction of the commutator, so that oil could not penetrate along the sides of the plate, and with care in preventing oil from getting on the commutator.

VIBRATING BRUSHES

There are a number of mechanical conditions entering into the practical side of commutation. It is important to maintain good contact between the brush face and the commutator in order to keep down losses and burning action. Therefore, if the brushes chatter or vibrate in their holders, or have a rocking action tending to give alternate "heel-and-toe" contact, the operation is likely to be affected thereby.

Vibrating brush holders may result from various causes which do not show up on the manufacturer's test. The machine may be so located that its environments are to blame for vibration. Bad gearing may cause chattering, or the foundations or supports may not be as substantial as on the shop test, so that some small disturbances may be

exaggerated and produce vibrations in parts or in the whole machine. Sometimes the brushes may chatter due to lack of lubricant, and this may set the whole brush holder structure into vibration.

Vibration of brushes in their boxes may be due to badly fitted brushes, or, on machines which have long been in operation with heavy currents per brush, the brush boxes may be eaten away inside so that they are not of uniform dimensions. Low resistance shunts on carbon brushes are for the purpose of carrying away the current from the brush by some other path than through the sides of the brush box. However, due to the dragging action of the commutator on the brushes, they are liable to bear rather heavily against one side of the box, especially at the lower edge next to the commutator. Some current will naturally pass to the box, and this in time will tend to burn away the boxes and the carbons. The brush then fits tightly only at the top and is free to vibrate or chatter at the commutator end, which is just the place where such movement should be avoided.

Chattering is not infrequently due to lack of lubrication of the commutator or brushes. When the commutator becomes too dry and has a high polish, a radial, or almost radial brush may vibrate or chatter just as a pencil does when moved along a pane of glass. If the commutator is lubricated with oil to overcome this, care should be taken not to use an excess of oil or the mica may absorb it. Frequently, immediately after oiling, a commutator shows ringfire which is due to combustion of minute particles of carbon and oil over the top of the mica. Sometimes chattering is best overcome by the use of self-lubricating brushes In undercut commutators, the slots are liable to cause chattering with nonlubricated brushes, giving out a noise of a pitch comparable with the product of the revolutions by the number of commutator bars. As oil lubrication should be used with caution on undercut machines, practice now usually calls for some form of self-lubricating brush, partly or wholly graphite.

In commutating pole machines it is especially important that the brushes should not have any heel-and-toe movement, for when the brush makes contact at one edge or the other, the result is equivalent to rocking the brushes backward or forward, which, as explained before, is particularly objectionable in such machines.

BURNT SPOTS

Burnt or black spots will sometimes develop on the commutator at points removed from each other a distance corresponding to that between holders of the same polarity. This is sometimes very bothersome, and the cause is not always easy to find. Any condition which produces one bad spot may tend to produce similar spots symmetrically displaced around the commutator. When one spot is formed, then when this spot passes under one brush arm, the brush contacts at this arm are naturally poorer and the other brush arms of the same polarity tend to take the load, and the current density in their brushes is correspondingly increased during this short period. If there is any tendency toward high mica, for instance, then the increased current at these points will produce increased burning away of the copper and burnt spots may develop.

SHORT-CIRCUITS

One of the most severe conditions that a direct-current generator can encounter is a dead short-circuit across its terminals, or in the immediate neighborhood of the machine. Few machines outside of those of comparatively small capacity and low voltage, can stand such a short circuit without severe flashing. Tests have shown that moderately large direct-current generators will give, at the moment of short-circuit, from 20 to 30 times full-load current. No ordinary commutating machine can be built to take care of such a current rush, and vicious arcing and flashing generally result. Fortunately, however, the majority of short-circuits occur at some distance from the generator, and in many cases, are made through arcs rather than by direct contact, so that the generators do not get the maximum rush of current.

It might be suggested that quick-acting circuit-breakers would take care of such extreme conditions by opening at the loads for which they are set. But this setting is that at which the tripping mechanism works, and if the current rises rapidly enough, it may be far in excess of the tripping value by the time that the breaker actually opens the circuit. In fact, this is just what happens in the case of a severe short-circuit. Oscillograph tests have shown that the current rush on short-circuit may reach its maximum value in one-fiftieth of a second, or even less, while the ordinary commercial circuit-breakers seldom operate in less than one-tenth of a second.

National Association of Cotton Manufacturers

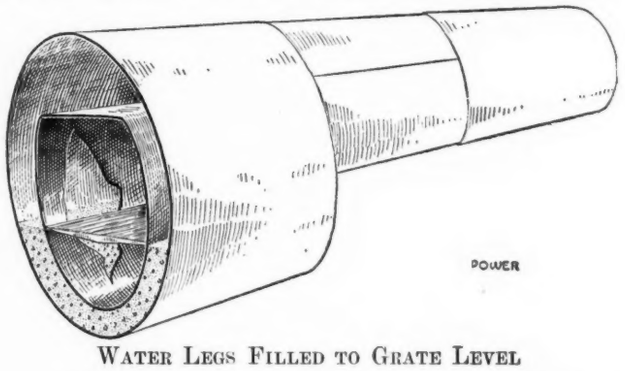
The ninety-seventh meeting of the National Association of Cotton Manufacturers, held at the Hotel Aspinwall, Lenox, Mass., Sept. 29 to Oct. 1, was attended by 200 to 300 members and guests. President Albert Greene Duncan delivered a masterly address in which he reviewed the general financial and commercial situation and stated that spinning and weaving of cotton cloth was the first industry in America to leave the home for the factory; from small beginnings it has built up an invested capital of at least $843,000,000 and is one of the few industries against which no charges of illegal combination or any of the other wrongs so bitterly complained of have ever been made.

Several valuable papers were presented on the cotton industry from cultivation of the staple to marketing of the finished product. The paper by Albert F. Bemis of Boston on "Textiles on the River Hooghly," India, describing methods of mill construction and operation in India and illustrated by stereopticon views was especially interesting from an engineering as well as manufacturing viewpoint. Francis W. Dean read a paper on "Sources of Power," in which he reviewed the forms of modern prime movers and gave interesting statistics of coal and fuel oil production.

The meeting was closed by a banquet at which Hon. W. P. G. Harding of the Federal Reserve Board, Washington, D. C., delivered an address upon "Cotton as a National Asset."

An Explosion Not Mysterious

On Aug. 19, the locomotive type boiler of a portable engine exploded at a shingle mill near Grampian, Penn., causing the loss of two lives. There is some doubt about the age of the boiler; it was between 20 and 30 years old, however. An examination after the explosion showed that the water bottom and water legs had at some previous time



WATER LEGS FILLED TO GRATE LEVEL

been filled with concrete, probably to stop leaks, to the level of the grates. The boiler was hired for temporary use and it is likely that it was not known to be loaded. As a matter of precaution, the pressure had lately been reduced from 120 to 90 lb., because of continual signs of distress.

There were no indications on the crown sheet of low water. There were, however, upward of 50 defects in the firebox alone which would justify an inspector condemning the boiler. As there is no compulsory inspection law in this state, nothing can prevent anyone selling or using such a boiler.

Southern Power Plants Merge

Street railway and power companies throughout middle and east Tennessee have been brought into close affiliation as a result of the formation of a holding company which has taken over the Clark interests for the purpose of promoting economical administration. The company is known as the Tennessee Railway, Light & Power Co. It holds a majority of the stock of the Nashville Railway & Light Co., the Tennessee Power Co., which owns the Ocoee River power plant; the Chattanooga Railroad & Light Co., and companies at Sparta, Cleveland and a number of other towns in Tennessee. It does not control the street railroad company at Knoxville, but supplies current to it and to the city of Knoxville.

It is also learned from an authoritative source that the Clark interests have entered into a contract with the Brady interests, which own and operate the mammoth power plant at Hale's Bar, on the Tennessee River, for the purchase of current.

The Franklin Medal

In December of 1913, President Samuel Insull, of the Commonwealth Edison Co., Chicago, stated that he had been informed that the board of managers of the Franklin Institute of Pennsylvania desired to found the Franklin Medal. The purpose was to award it in recognition of individual contributions to science or to the application of physical science to industry.

In March of this year Mr. Insull and the board of managers having mutually fixed upon the conditions attending the award of the Franklin Medal, Mr. Insull forwarded his check for $6000. This money has been so invested that the income will enable the board from time to time to strike off and award medals to those who have, in the estimation of the institute, earned them by their work in physical science or technology.

As is indicated by the illustrations, the medal is beautifully modeled, the design having been made by R. Tait McKenzie; the medallion of Franklin is taken from Sully's portrait, in the possession of the institute. Its intrinsic value is about $75.

Obverse

Reverse

THE FRANKLIN MEDAL

Founded Jan. 1, 1914, by Samuel Insull

Atlantic G. & E. Co. Files Bankruptcy Plea

Liabilities of $2,478,212 were given in a voluntary petition in bankruptcy filed in the United States District Court on Oct. 29 by the Atlantic Gas & Electric Co., 25 Broad St., New York City. The actual value of the assets is not known, but their face value is estimated at more than $5,000,000. The assets include materials and supplies valued at $20,000 in the possession of the Pennsylvania Utilities Co., Easton, Pa., one of the bankrupt company's subsidiaries. They also include bond and note claims against the subsidiary companies amounting to $5,238,710. The company also holds stocks and bonds of the subsidiary companies worth $1,143,817, and $460,500 worth of its own stocks and bonds. It controls the following properties: The Eastern Pennsylvania Power Co. of New Jersey, the Easton Gas Works, the Interurban Gas Co., the Pennsylvania Utilities Co., the Binghamton Light, Heat & Power Co., the Sayre Electric Co., the Jersey Corporation, the Chemung Land Co.

Of the liabilities $2,420,852 are unsecured and there is owed $550 in salaries and $28,286 to its subsidiaries. The company has two outstanding bond issues aggregating $3,815,551, secured by a mortgage to the Atlantic Trust Co., Boston.

Among the stocks and bonds of the subsidiary companies which the parent concern includes in its assets are $2,217,200 of the securities of the Pennsylvania Utilities Co.

The Atlantic Gas & Electric Co. was incorporated under the laws of Connecticut on April 2, 1912, for the purpose of acquiring control of established gas and electric properties through the securities of the companies holding them, and to provide through its working capital independent banking facilities for improvements, extensions and betterments for those properties and to operate them.

The authorized capital stock comprises $5,000,000 six per cent. cumulative preferred and $7,500,000 common. Of these amounts $1,561,900 preferred and $3,361,400 common were outstanding on Dec. 31, 1913. The officers are Arthur D. Lord, president, New York; Carl M. Pihl, vice-president, Easton, Penn.; F. V. Shannon, treasurer, and A. B. Cheadle, secretary.

Boiler Explosion at Storrs, Utah

On Sept. 28, about 8 o'clock a.m., a boiler explosion of unusual violence occurred at the mines of the Spring Cañon Coal Co., Storrs, Utah, 115 miles east of Salt Lake City. Two men were killed outright and five others were seriously injured. The boiler was of the Continental marine type built by the Springfield Boiler Works less than two years ago.

It appears that the furnace had been overheated, probably due to low water, and the upper side had sagged about 4 in. at a point 5 ft. from the fire door. Repairs had been made and after a satisfactory hydrostatic test on Sunday, the boiler was prepared for duty Monday morning. As the steam approached the working pressure, which was 150 lb., but before the boiler was "cut in," the master mechanic (one of those killed) ordered the fireman to pull the fire as the boiler showed signs of distress. Before the pressure could be reduced the boiler exploded and was hurled through the roof to the hillside 100 yards distant.

The stone walls of the boiler house, which were over 2 ft. thick, were demolished at the front and rear of the wrecked boiler, although the other boilers of the battery, two on each side, were uninjured. The damage will amount to upward of $20,000.

ERRATA—On page 396, Sept. 15, the third paragraph should read: Before paragraph 40—All staybolts shall be drilled, both from the outside and inside ends, to a depth of not less than one-half inch (½ in.) inside the boiler plate, and their diameter shall be **not less than** three-sixteenths of an inch ($\frac{3}{16}$ in.) and,

Before paragraph 41—All boilers and parts of boilers shall be securely riveted, not bolted.

BOOKS RECEIVED

OIL FUEL. By Edward Butler. J. B. Lippincott Co., Philadelphia, Penn. Third edition. Cloth; 328 pp., 5¼x8 in.; 145 illustrations; tables.

MECHANICS AND HEAT. By William B. Anderson. McGraw-Hill Book Co., Inc., New York. Cloth; 349 pp., 6x9 in.; 153 illustrations. Price $2.

PRACTICAL MATHEMATICS FOR ENGINEERS. By F. Hovenden. D. Van Nostrand Co., New York. Cloth; 144 pages, 5x7½ in.; illustrated. Price, $1.

SCIENCE AND PRACTICE OF MANAGEMENT. By A. Hamilton Church. The Engineering Magazine Co., New York. Cloth; 535 pages, 5x7½ in. Price, $2.

MECHANICS FOR MARINE ENGINEERS. By A. N. Somerscales. D. Van Nostrand Co., New York. Cloth; 277 pages, 4¾x7¼ in.; 149 illustrations. Price, $1.50.

FUEL: GASEOUS, LIQUID AND SOLID. By J. H. Coste and E. R. Andrews. J. B. Lippincott Co., Philadelphia, Penn. Cloth; 278 pp., 5¼x7¾ in.; 63 illustrations; tables.

HIGH-POWER GAS ENGINES. By H. Dubbel. D. Van Nostrand Co., New York. Cloth; 197 pages, 7½x11 in.; 423 illustrations; 13 folding plates. Price, $5.

INDICATOR DIAGRAMS FOR MARINE ENGINEERS. By W. C. McGibbon. D. Van Nostrand Co., New York. Cloth; 182 pages, 7¼x9¾ in.; 197 illustrations; tables. Price, $3.

HANDBOOK OF TABLES AND FORMULAS FOR ENGINEERS. By Clarence A. Peirce and Walter B. Carver. Leather; 168 pp., 4x7 in.; illustrated; tables. Price, $1.50.

SIMPLE PROBLEMS IN MARINE ENGINEERING DESIGN. By J. W. M. Sothern and R. M. Sothern. D. Van Nostrand Co., New York. Third edition; cloth; 191 pages, 5x7¾ in.; tables. Price, $1.

ELEMENTARY MATHEMATICS FOR MARINE ENGINEERS. By J. W. M. Sothern and R. M. Sothern. D. Van Nostrand Co., New York. Cloth; 174 pages, 5x7¾ in.; illustrated; tables. Price, $1.

MARINE ENGINEERING RULES AND TABLES. By A. E. Seaton and H. M. Rounthwaite. D. Van Nostrand Co., New York. Twelfth edition; leather; 713 pages, 4x6½ in.; illustrated; tables. Price, $3.50

"VERBAL" NOTES AND SKETCHES FOR MARINE ENGINEERS. By J. W. M. Sothern. D. Van Nostrand Co., New York. Eighth edition; cloth; 676 pages, 6x9⅛ in.; 545 illustrations; 10 folding plates; tables. Price, $5.

ENGINEERING AFFAIRS

Public Lectures in New York City—The department of education of the City of New York, under the supervision of Henry M. Leipziger, offers a number of lectures for this fall and winter of interest to electrical men. Among the subjects are "Wonders of Electrical Inventions," "Principles and Practice in Electrical Engineering," "Electricity and Magnetism." These lectures will be given in the city's public school halls and the dates and names of the lecturers have been prominently posted.

Evening School of Engineering at University of Pittsburgh—The Evening School of Engineering giving graduate courses will be a new feature at the University of Pittsburgh this autumn. It is the first time this kind of work has been attempted in this country, although several day schools offer graduate work.

In the Pittsburgh district there are more engineering graduates than in any equal district in the United States. It is for this reason that the university will provide for men who do engineering work during the day an opportunity to study engineering in the evening. Men who are properly prepared and who have received their bachelor of science degree may obtain an engineering degree from the University of Pittsburgh.

Many young engineers find after engaging in practical work that the courses which they took in college did not fully prepare them for their duties. Few have opportunity to quit work and go back to their own college for further study, but many can devote their evenings to new courses.

Courses will be offered in the valuation of public utilities, mechanical, civil, electrical, sanitary, mechanical, railway, concrete engineering, etc. The faculty will include some of the best engineers in the Pittsburgh district.

The New York School of Heating and Ventilating Class will meet Monday evening of each week at 7:30 o'clock in room 511, World Bldg., Park Row, New York, under the direction of Charles A. Fuller, consulting engineer with Messrs. Clark, MacMullen & Riley. Mr. Fuller has been engaged for a number of years in the design and supervision of heating and ventilating work for all classes of buildings, is a graduate of the University of Michigan, and has had successful experience as instructor in mechanical engineering at the University of Pennsylvania. He is, therefore, well fitted to offer the best instruction in the most recent practice.

The course consists of 22 lectures covering the subjects of heating and ventilating with special reference to computation of heating surfaces, pipe sizes, boilers, etc., for gravity and vacuum steam systems; for gravity and forced hot water systems; sizes of ducts, fans and heaters for various kinds of ventilating systems; purification of air and humidifying devices. No particular requirements as to education and mathematics are necessary as the various subjects are handled in such a manner as to eliminate the more difficult mathematical calculations.

The fee for the complete course will be $10, payable in advance. The first meeting will be held on Nov. 2. All who wish to join the class should be on hand promptly at that time.

PERSONALS

Walter B. Snow, publicity engineer, has removed his offices to rooms 511-516, in the new Federal St. building, 136 Federal St., Boston, Mass. This organization, built up during the past seven years, will be better equipped to act as publicity managers and general advertising agents.

Martin R. Carpenter, refrigerating engineer, has opened an office in Cincinnati, Ohio, where he will make a specialty of ice and cold-storage plants and consultation work along refrigeration lines. Mr. Carpenter was with the Triumph Ice Machine Co. for eight years, four of which he was its chief engineer.

Thomas Hawksworth has been appointed chief engineer at the Brilliant pumping station, Pittsburgh, Penn. He succeeds H. E. Fernald, who resigned because he is removing to Maine, where he has important business interests. Mr. Hawksworth has been an assistant engineer at the pumping station about 12 years.

Frederick R. Hutton, consulting engineer of the Automobile Club of America, will address the joint meeting of the Engineers' Club of Cincinnati, and the Cincinnati Section, A. S. M. E., Oct. 15, at 8 p.m., in the Literary Club Auditorium. The address will be on the subject, "The Testing of the Motor-Vehicle Engine," and illustrated with stereopticon views. Mr. Hutton was honorary secretary of the American Society of Mechanical Engineers, 1833-1906, president of the society, 1907, and is now emeritus professor of mechanical engineering, Columbia University.

STATEMENT OF THE OWNERSHIP, MANAGEMENT CIRCULATION, ETC., OCT. 1, 1914,

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The balance of the stock issued (less than 1% each) is owned by 70 employees, 3 ex-employees, and 14 others who are wives, daughters or relatives of employees.

Known bondholders, mortgagees, and other security holders holding 1 per cent. or more of total amount of bonds, mortgages or other securities: Mortgage on building held by Dime Savings Bank, Brooklyn, N. Y.

C. W. Dibble, Vice-President,
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 30th day of September, 1914.

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1915.)